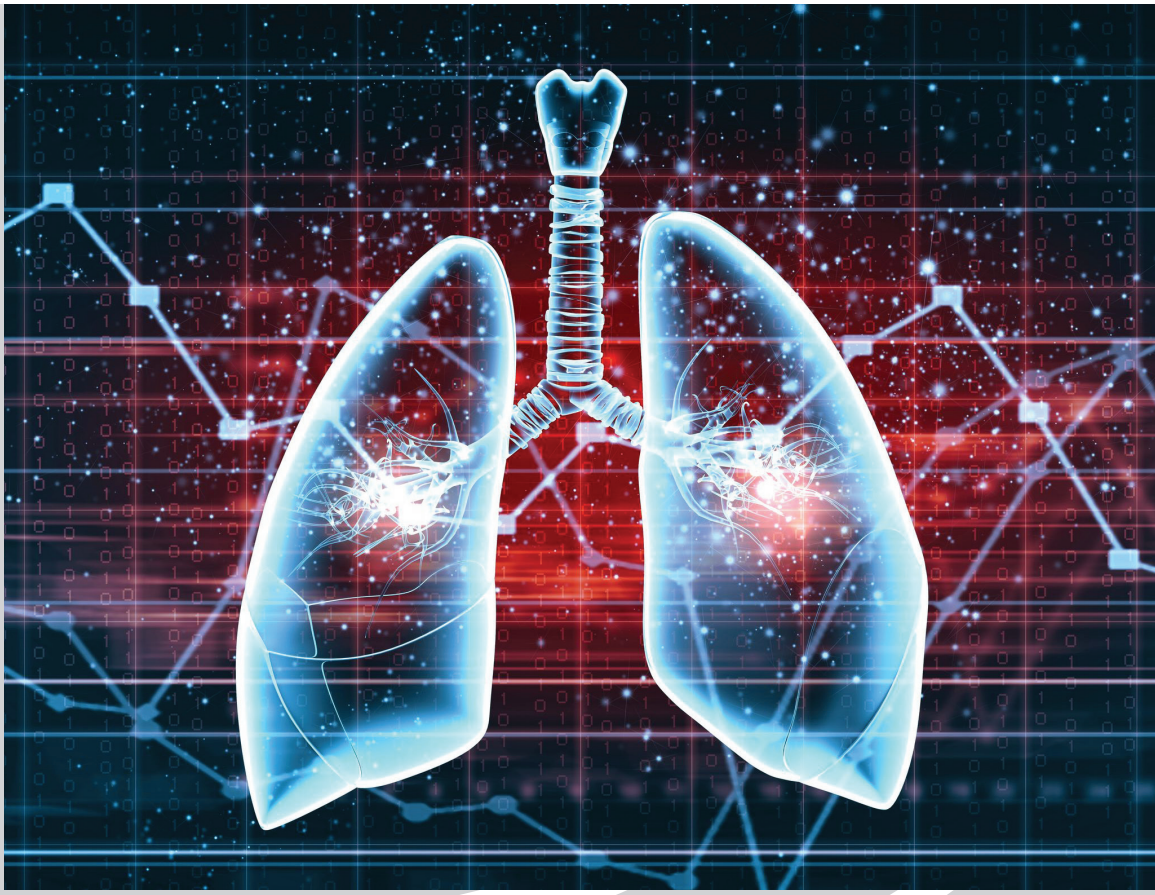
Inspiring Change

A review of the quality of care provided to patients receiving acute non-invasive ventilation



NCEPOD

Improving the quality of healthcare

Inspiring Change

A review of the quality of care provided to patients receiving acute non-invasive ventilation

A report published by the National Confidential Enquiry into Patient Outcome and Death (2017)

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Contents

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Foreword

This report focuses on a common and important area of acute clinical care in our hospitals - non-invasive ventilation (NIV). It is the first time that the topic has been examined in such depth and provides an excellent example of how a national audit and a national confidential enquiry can work in partnership to identify ways in which we can improve the care of our patients.

The study was proposed by the British Thoracic Society (BTS) who have undertaken several previous audits on acute non-invasive ventilation and have reported an increase in hospital mortality rates. Whilst an increasingly ageing and sicker population were considered to be potential contributory factors to account for this increase, the possibility that there may be additional factors adversely affecting the quality of care provided to these patients was another reason for performing the study. At all stages of our topic selection process, it was considered that the detailed review of case notes that NCEPOD methodology employs was an ideal way to answer some of the questions raised by the national audit. The findings have provided us with an even more detailed picture than we were expecting, which will have significant ramifications for this group of patients.

Acute NIV is used in an increasingly large number of patients since it is most commonly employed in the treatment of chronic obstructive pulmonary disease (COPD). COPD is the 2nd most common reason for hospital admissions and the 5th biggest killer in the UK, accounting for 25% of all deaths from lung disease. Hence, ensuring that appropriate treatment is available in our hospitals is of major importance.

Sadly, our study found that this was not always the case. There was wide variation in both the organisation of acute NIV services and the clinical care provided. Nevertheless, since we designed the study to identify areas of clinical care that can be improved, it is important to note that some of the cases reviewed demonstrated good service design and/or high quality clinical care. The picture, however, was mixed and there were important lessons to be learned in a high proportion of the cases reviewed which we are highlighting in order to achieve improvements for the whole service.

The reviewers found that NIV treatment was often delayed due to the recognition of which patients would benefit from NIV or appreciating the ultimate goal of the treatment provided. As a result we found cases where NIV was commenced but where palliative care would have been a more appropriate option. Furthermore, even when used appropriately the NIV treatment delivered was often felt to be sub-standard or ineffective. This was demonstrated clinically with inadequate monitoring of vital signs and blood gases and lack of an escalation plan being in place at the start of treatment. Furthermore, organisation of care highlighted concerns in the inadequate levels of nursing staffing to deliver the NIV treatment, the location in which NIV was delivered being inappropriate and the application of ventilator settings, and changes to these, which were often poorly documented or non-existent.

Overall, the care of patients in this study was rated as less than good in 80% of the cases reviewed, with clinical care being one of the biggest areas of concern at 34% and a combination of clinical and organisation of care in 27%. The NIV care alone was rated as good in 27%, adequate in 35% and as poor or unacceptable in 23% of patients.

One important issue is that many hospitals fail to grasp the size of the problem, as acute NIV usage is all too easily hidden from view due to poor coding. The inaccuracy of clinical coding for NIV is one area that could be so easily fixed at a national level and would support our clinicians and hospital managers in improving patient care. Inadequate coding is an issue regularly highlighted by NCEPOD (for example in our recent tracheostomy, sepsis and acute pancreatitis reports). Indeed poor coding is well recognised as a Cinderella area in many other areas of our

healthcare system. If we do not know how many patients are being treated with acute NIV, how can we expect our healthcare providers to be able to plan effectively?

In this instance, the procedure code used for NIV in national coding is also used for continuous positive airway pressure (CPAP); a similar but different treatment that is used for very different reasons. This means that the recorded usage of both is inaccurate and hospitals are unable to easily measure quality indicators in this group. We found that fewer than half of hospitals reported that they audited their own practice, despite the fact that nearly a third had reported a clinical incident related to patients receiving NIV in the year we collected data. One of the main reasons cited for the clinical incidents being lack of available equipment. Nearly 40% of hospitals reported that in the previous 12 months there had been times when they had more patients requiring NIV than their capacity to deliver it.

In order to improve the outcomes for patients receiving acute NIV, NCEPOD is calling for hospitals to appoint local champions to examine and challenge the provision of acute NIV services in their hospital and ensure well designed services with sufficient staff who are competent in both prescribing and treating patients who need NIV.

For clinicians, we would like to emphasise the importance of case selection, regular patient assessment, specialist involvement and a clear understanding of the clinical factors that influence treatment outcome.

As with all NCEPOD reports I must acknowledge the enormous effort that has gone into this study. I would like to thank the British Thoracic Society for proposing the study, the NCEPOD Steering Group representing the Royal Colleges, Faculties and Specialist Associations for appreciating the clinical concerns and short listing the topic and the multidisciplinary study advisory group and patient representative who knew so much more about this topic than we did and so helped to design the study and advised as to the questions we needed to ask. Thank you also to the case reviewers who generously gave up their time and to each clinician who painstakingly completed the lengthy questionnaire. The NCEPOD Local Reporters identified the cases for us, copied the notes and understood the need for reselection in cases of poor coding. Further thanks are due to our NCEPOD Ambassadors who championed the topic locally, the authors for writing such a detailed report, the researchers for their analysis and guidance on interpreting the data, the whole of the NCEPOD team for running the study to schedule and to our panel of lay representatives for their invaluable insight and non-clinical interpretation of the findings. Finally I thank my fellow Trustees and our clinical co-ordinators for all their support.

Professor Lesley Regan
NCEPOD Chair

Principal recommendations

All hospitals should have a clinical lead for their acute non-invasive ventilation (NIV) service. The clinical lead should have time allocated in their job plan with clear objectives, including audit and governance for this service. *(Medical Directors and Nursing Directors)*

Treatment with acute non-invasive ventilation (NIV) must be started within a maximum of one hour of the blood gas measurement that identified the need for it, regardless of the patient's location. A service model whereby the NIV machine is taken to the patient to start treatment prior to transfer for ongoing ventilation will improve access to acute NIV. *(All Clinical Staff Providing Acute Non-Invasive Ventilation and Acute Non-Invasive Ventilation Service Leads)*

All hospitals where acute non-invasive ventilation (NIV) is provided must have an operational policy that includes, but is not limited to:

a. Appropriate clinical areas where acute NIV can be provided, and in those areas the minimum safe level of staff competencies;
b. Staff to acute NIV patient ratios;
c. Escalation of treatment and step down care procedures;
d. Standardised documentation; and
e. Minimum frequency of clinical review, and seniority of reviewing clinician

Compliance with this policy should be part of the annual audit process. *(Medical Directors, Nursing Directors and Acute Non-Invasive Ventilation Service Leads)*

**See Appendix 1 – British Thoracic Society competency checklist www.brit-thoracic.org.uk/ standards-of-care/guidelines btsrcpics-guideline-for-non- invasive-ventilation/*

All patients treated with acute non-invasive ventilation (NIV) must have a treatment escalation plan in place prior to starting treatment. This should be considered part of the prescription for acute NIV and include plans in relation to:

a. Escalation to critical care;
b. Appropriateness of invasive ventilation; and
c. Ceilings of treatment.

This should take into account:

d. The underlying diagnosis;
e. The risk of acute NIV failure; and
f. The overall management plan.

(All Clinical Staff Responsible for Starting Acute NIV)

**See Appendix 1 – British Thoracic Society NIV prescription chart www.brit-thoracic.org.uk/ standards-of-care/guidelines/btsrcpics-guideline-for-non- invasive-ventilation/*

All patients treated with acute non-invasive ventilation (NIV) must be discussed with a specialist competent in the management of acute NIV at the time treatment is started or at the earliest opportunity afterwards. Consultant specialist review to plan ongoing treatment should take place within a maximum of 14 hours. *(Acute Non-Invasive Ventilation Service Leads)*

All patients treated with acute non-invasive ventilation must have their vital signs recorded at least hourly until the respiratory acidosis has resolved. A standardised approach such as the National Early Warning Score is recommended. *(Nurses and Acute Non-Invasive Ventilation Service Leads)*

**See Appendix 4 – National Early Warning Score (NEWS) www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news*

All hospitals should monitor their acute non-invasive ventilation mortality rate and quality of acute NIV care. This should be reported at Board level. *(Chief Executives, Medical Directors, Nurse Directors and Acute Non-Invasive Ventilation Service Leads)*

Please see page 95 for the full list of recommendations.

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Introduction

Whilst this is a report looking at the care provided to patients receiving acute non-invasive ventilation (NIV), it must be noted that the most common condition that NIV is used for in hospital is chronic obstructive pulmonary disease (COPD). COPD accounts for around 25% of deaths from lung disease, is the fifth biggest killer disease in the UK and with around 115,000 emergency hospital admissions per year is the second most common reason for hospital admission.

Approximately 20% of patients with COPD present to hospital in acidotic ventilatory failure (elevated carbon dioxide, CO_2). Once CO_2 levels have started to rise, a small further reduction in breathing will lead to a larger rise in CO_2 levels and worsening of acidosis. This leads to a downward spiral and eventually, coma and death. Rapid access to treatment as soon as possible after respiratory acidosis develops is therefore important. NIV can provide this support by using a mask or similar device to attach a ventilator to the patient.

A key study in 2000 demonstrated the effectiveness of NIV delivered by nursing staff on respiratory wards in the UK.[1] NIV reduced mortality from 20% to 10% when compared to standard care. Although NIV was shown to be safe and effective when delivered in a ward environment by nurses, this was in a clinical trial and the survival advantage was limited to patients with less severe acidosis (pH 7.25-7.35).

It is recommended that all patients admitted to hospital with COPD with acidotic ventilatory failure should receive NIV delivered by appropriately trained staff in a dedicated setting.[2] NIV therefore needs to be widely available in clinical practice to achieve this standard. However, the availability of NIV means that patients with non-COPD diagnoses are increasingly being treated with it. These patients often require a more complex approach to ventilation. Mortality rates are also higher in patients with diagnoses such as cardiogenic pulmonary oedema and pneumonia treated with NIV.[3]

There is wide variation in how hospital NIV services are organised. In some hospitals it is delivered in intensive care or specialist respiratory high dependency units and in others, on the medical wards. Acute non-invasive ventilation is a specialist procedure. Introduction on general wards means that it can be initiated by non-specialists and often junior staff working out of hours.

The British Thoracic Society (BTS) has conducted an annual audit of NIV since 2010.[3-5] This has included patients with any diagnosis leading to treatment with acute NIV in hospitals in the UK. In the last three audit periods the dataset has shown an increase in mortality rates rather than an improvement. The audit data raises a number of important questions about both the organisation of services and the care delivered to patients receiving NIV. These include whether the correct patients are being treated with NIV, whether treatment is being delayed inappropriately and whether better escalation of treatment to critical care is needed. It also raises questions about whether services for NIV are organised in a way that ensures it is commenced by appropriately trained staff and delivers the most effective results.

The study presented in this report was proposed to answer these questions about the care received by patients treated with acute NIV in hospital in the United Kingdom.

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Method and Data Returns

Method

Study Advisory Group

The Study Advisory Group (SAG) comprised a multidisciplinary group of clinicians in: respiratory medicine, acute medicine, critical care, anaesthesia, emergency medicine, specialist respiratory physiotherapy, respiratory specialist nursing, a patient treated with NIV and a lay person.

Study aim

To identify and explore avoidable and remediable factors in the process of care for patients treated acutely with non-invasive ventilation (NIV).

Objectives

The Study Advisory Group identified a number of objectives that would address the primary aim of the study:

- Prompt recognition of ventilatory failure and rapid initiation of NIV
- Appropriate documentation and management of ventilator settings to correct respiratory failure
- Escalation of treatment decisions and planning including admission to critical care
- Assessing multidisciplinary team approach
- Assessing the adequacy of communications with families and carers
- Examining the management of the 'acute' end of life pathway and ceilings of treatment including appropriateness of NIV as an intervention
- Organisational aspects of care delivery for NIV on acute, general or respiratory wards to include aspects of staff training

Hospital participation

National Health Service hospitals in England, Scotland, Wales and Northern Ireland were expected to participate as well as public hospitals in the Isle of Man, Guernsey and Jersey.

Within each hospital, a named contact, referred to as the NCEPOD Local Reporter, acted as a link between NCEPOD and the hospital staff, facilitating case identification, dissemination of questionnaires and data collation.

Study population and case ascertainment

Patients aged 16 years or older who were admitted as an emergency between 1st February 2015 and 31st March 2015 inclusive, and who received NIV acutely.

Exclusions

Patients already on active treatment with long-term NIV at home.

Case identification using the OPCS code for NIV

The standard procedure code (OPCS code) for NIV is E85.2. This code includes continuous positive airways pressure (CPAP), intermittent positive pressure ventilation (IPPV) and negative pressure ventilation (NPV).

Non-invasive ventilation is a treatment which is used to improve CO_2 elimination. CPAP is a form of respiratory support which is used either to improve oxygenation or to act as a splint to maintain patency of the upper airway. It does not improve CO_2 elimination and was not therefore included in this study. Since the introduction of IPPV, NPV is rarely used. The machines currently used to deliver NIV and CPAP often look similar.

For the purposes of this study the term NIV applies to IPPV within this OPCS code. It was clear from entries in the case notes submitted for this study that there is a poor clinical understanding of the difference between NIV and CPAP.

The use of the term NIV as a code that includes a form of respiratory support that is not ventilation is unhelpful. This adds to the poor understanding of the difference between ventilation and CPAP that is seen clinically. There are important differences between the indications for ventilation and CPAP. Confusion can have adverse effects on patient care. Avoiding this confusion is therefore of great importance. The effect of the mixed use of the code was demonstrated clearly in the cases identified, and the high number of cases that had to be excluded in this study (Figure 1.1).

Questionnaires and case notes

Two questionnaires were used to collect data for this study; a clinician questionnaire for each patient and an organisational questionnaire for each hospital participating in the study.

Clinician questionnaire

This questionnaire was sent to the consultant responsible for the patient at the time of their discharge or death. If that consultant was not the most suitable person to complete the questionnaire they were asked to identify a more appropriate consultant. Information was requested on the patient's presenting features/comorbid conditions, initial management, investigations, NIV treatment, complications, escalation in care, follow-up and outcome.

Organisational questionnaire

The data requested in this questionnaire included information on the staff that manage patients on NIV, locations where NIV patients were managed, guidelines and standard operating procedures relevant to the management of patients on NIV.

Case notes

Copies of case note extracts were requested for each case that was to be peer reviewed:
Final inpatient admission

- All inpatient annotations/medical notes for the patient's final admission
- Nursing notes
- Critical care notes
- Operation/procedure notes
- Anaesthetic charts
- Observation charts
- Haematology/biochemistry results
- Fluid balance charts
- Blood transfusion records
- Drug charts
- Nutrition/dietitian notes
- Consent forms
- Discharge letter/summary
- Autopsy report if applicable

Peer review of the case notes and data

A multidisciplinary group of case reviewers was recruited to peer review the case notes and associated clinician questionnaires. The group of case reviewers comprised consultants, trainees and clinical nurse specialists, from the following specialties: respiratory medicine, anaesthesia, intensive care medicine, high dependency medicine, acute medicine, physiotherapy and respiratory nursing.

Questionnaires and case notes were anonymised by the non-clinical staff at NCEPOD. All patient identifiers were removed. Neither the Clinical Co-ordinators at NCEPOD, nor the case reviewers, had access to patient identifiable information.

After being anonymised, each case was reviewed by at least one reviewer within a multidisciplinary group. At regular intervals throughout the meeting the Chair allowed a period of discussion for each reviewer to summarise their cases and ask for opinions from other specialties or raise aspects of the case for discussion.

Case reviewers answered a number of specific questions using a semi structured electronic questionnaire and were encouraged to enter free text commentary at various points.

The grading system below was used by the case reviewers to grade the overall care each patient received:

Good practice: A standard that you would accept from yourself, your trainees and your institution.
Room for improvement: Aspects of **clinical** care that could have been better.
Room for improvement: Aspects of **organisational** care that could have been better.
Room for improvement: Aspects of both **clinical and organisational** care that could have been better.
Less than satisfactory: Several aspects of clinical and/or organisational care that were well below that you would accept from yourself, your trainees and your institution.
Insufficient data: Insufficient information submitted to NCEPOD to assess the quality of care.

Information governance

All data received and handled by NCEPOD complies with all relevant national requirements, including the Data Protection Act (DPA) 1998 (Z5442652), the NHS Act 2006 (PIAG 4-08(b)/2003, App No 007) and the NHS Code of Practice.

Quality and confidentiality

Each case was given a unique NCEPOD number.
The data from all questionnaires received were electronically scanned into a preset database. Prior to any analysis taking place, the data were cleaned to ensure that there were no duplicate records and that erroneous data had not been entered during scanning. Any fields that contained data that could not be validated were removed.

Data analysis

Following cleaning of the quantitative data, descriptive data summaries were produced.

The qualitative data collected from the case reviewers' opinions and free text answers in the clinician questionnaires were coded, where applicable, according to content to allow quantitative analysis. The data were reviewed by NCEPOD Clinical Co-ordinators, a Clinical Researcher and two Researchers to identify the nature and frequency of recurring themes.

Case studies have been used throughout this report to illustrate particular themes.

All data were analysed using Microsoft Access™ and Excel™ by the research staff at NCEPOD.

The findings of the report were reviewed by the Study Advisory Group, Reviewers, NCEPOD Steering Group including Clinical Co-ordinators, Trustees and Lay representatives prior to publication.

Data returns

In total 9,299 patients were identified as meeting the study inclusion criteria (Figure 1.1 overleaf). When the sampling criteria, of up to five cases per hospital was applied and 1152 cases were selected for inclusion in the main data collection. A large number of cases (474) were subsequently excluded (both originally sampled cases and reselections). In the large majority of cases (291) this was because the patient received CPAP rather than NIV. A total of 432/678 (64%) completed clinician questionnaires and 353 sets of case notes were returned to NCEPOD.

Within this study the denominator will change for each chapter and occasionally within each chapter. This is because data have been taken from different sources depending on the analysis required. For example, in some cases the data presented will be a total from a question taken from the clinician questionnaire only, whereas some analysis may have required the clinician questionnaire and the case reviewer's view taken from the case notes. The term 'clinician' is used to refer to data obtained from the clinician responsible for that patient's discharge and care and the term 'reviewer' used to refer to data obtained from the multidisciplinary group who undertook the peer review of case notes.

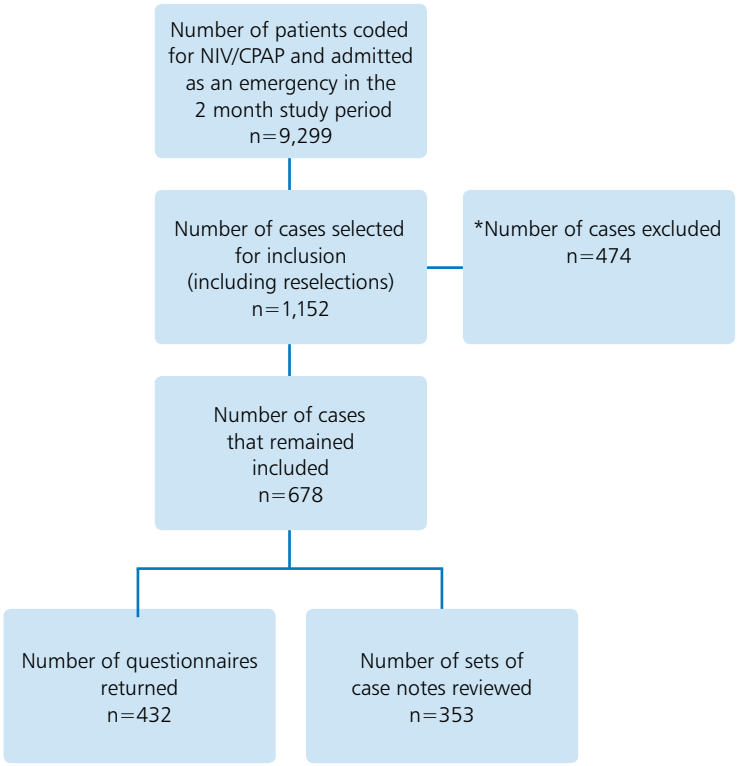

Figure 1.1 Data returns

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Organisational data

The national guidelines for non-invasive ventilation (NIV) include recommendations about how services should be organised. The 2008 guideline published jointly by the British Thoracic Society, the Royal College of Physicians of London and the Intensive Care Society was in place at the time patients in this study were treated.[6] The organisational questionnaire was designed to measure practice against these standards and was sent to every hospital where patients may be treated with NIV.

This section of the report covers the type of hospital, arrangements for acute NIV provision, staffing, facilities, and the policies and procedures in place for services providing care to patients requiring NIV.

Type of hospital from which an organisational questionnaire was received

Table 2.1 shows that all types of hospital provide NIV. Of the hospitals that provide this service 158/165 (95.8%) had an emergency department (data not shown). Critical care outreach services were also available in 143/166 (86.1%) hospitals.

Table 2.1 Type of hospital

	Number of hospitals	%
District General Hospital ≤ 500 beds	71	44.1
District General Hospital > 500	47	29.2
University Teaching Hospital	43	26.7
Subtotal	**161**	
Other/not answered	7	
Total	**168**	

The number of acute NIV episodes provided by all hospitals

The numbers of acute NIV episodes provided by all hospitals during the two month study period are listed in Figure 2.1.

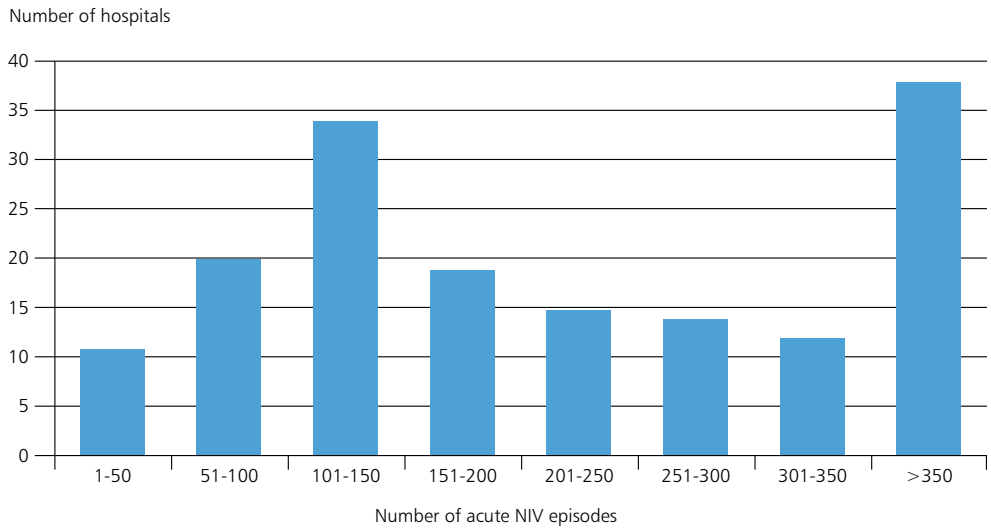

Figure 2.1 Annual acute NIV episodes

Despite guidelines recommending that a prospective register of patients receiving NIV is kept,[6] only 39/165 hospitals routinely collected data on the number of NIV episodes. The numbers provided were an approximation in 52/165 (31.5%) hospitals and derived from coding in 65/165 (39.4%). As already noted in Chapter 1, the code used for NIV also covers CPAP episodes and this treatment was commonly confused with NIV when cases were identified for this study. Numbers derived from coding are therefore likely to be inaccurate. NIV is also used in some hospitals post invasive ventilation to aid weaning. These cases would be included in coding but were not included in this study.

Guidelines have previously recommended that a 'designated expert' is available at all times to support the NIV service.[6] In 55.2% (91/165) of hospitals out of hours cover for the NIV service was provided exclusively via the general medical on call rota (data not shown). In 23.4% (37/158) of hospitals, NIV services were covered out of hours by a respiratory consultant all of the time. However, in 75.3% (119/158) of hospitals respiratory consultants provided cover for 50% or less of the out of hours time period. In fifteen hospitals there was no out of hours cover provided by a respiratory consultant (Figure 2.2).

NIV provision

The locations where NIV was initiated and continued are shown in Figure 2.3. It was reported from most hospitals that NIV would be initiated in the emergency department (89.1%; 147/165). Most would also initiate (81.8%; 135/165) and continue (81.7%; 134/164) NIV in the intensive care unit.

For service planning, it has been recommended that NIV services are arranged with the expectation that approximately 20% of patients with acute hypercapnic respiratory failure will require treatment in intensive care.[7]

Figure 2.4 shows the approximate percentage of NIV episodes provided in different clinical areas for the 101 hospitals from which a response to this question was received. In 14/101 hospitals NIV was provided exclusively in a critical care environment. In 63 hospitals, less than 20% of NIV episodes were provided in critical care and 36 hospitals provided more than 60% of NIV episodes on a general respiratory ward without a high care area. In 71/101 hospitals NIV was not provided in any areas other than the specialist areas already described.

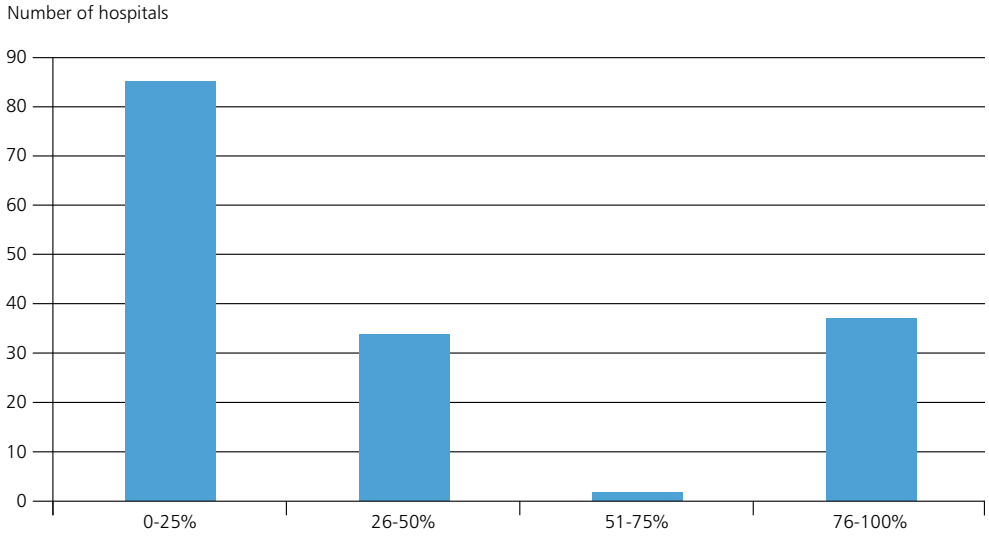

Figure 2.2 Percentage of out of hours coverage by a respiratory consultant

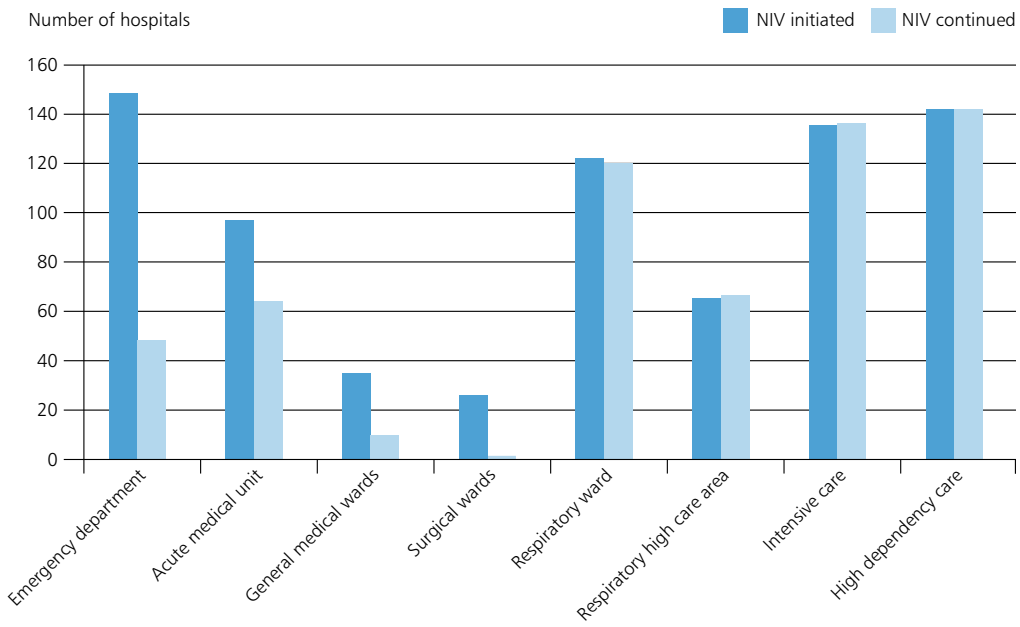

Figure 2.3 Locations where NIV was initiated and continued

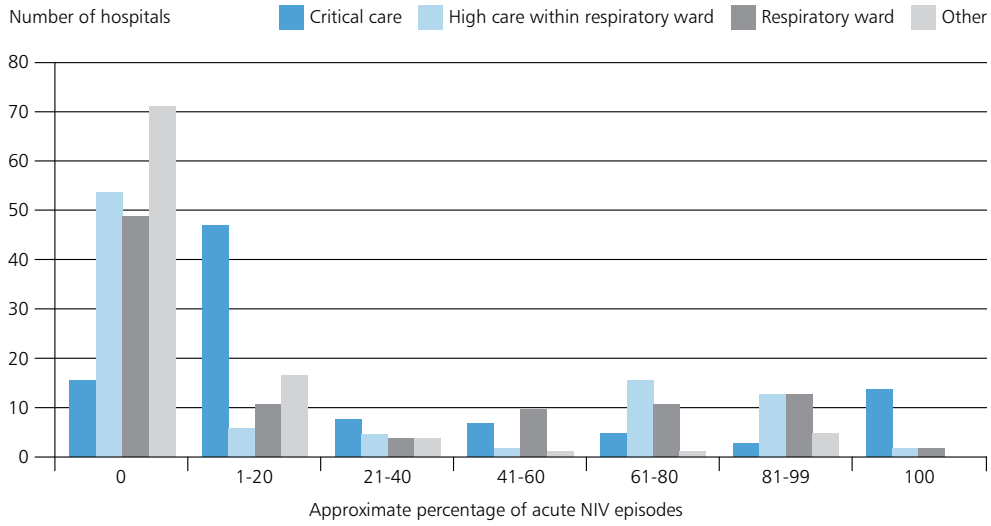

Figure 2.4 Approximate percentage of NIV episodes provided in different clinical areas

In order to maintain safe care, critical care areas (intensive care and high dependency care) have enhanced staffing ratios and are able to monitor vital signs continuously. Continuous monitoring of oxygen saturation is recommended for patients on NIV.[6]

Continuous ECG monitoring has also been recommended in the first twelve hours of NIV.[6] Figure 2.5 shows the frequency with which the non-critical care areas in the hospitals surveyed could provide the monitoring necessary for the care of NIV patients.

Continuous oxygen saturation monitoring was not available in all ward areas in all hospitals. It was only available on 98/121 respiratory wards and 26/35 general medical wards where NIV was used, and on 61/66 respiratory high care wards. Although continuous ECG monitoring was generally available in emergency departments, it was less frequently available on the wards, being used in 68/96 acute medical units and 44/66 respiratory high care areas, and less in other areas.

Invasive arterial monitoring requires more nursing supervision. It was being used on a small number of respiratory and acute medical wards. More detailed information about local arrangements on these wards was not collected.

In addition to vital signs monitoring, the effectiveness of ventilation is assessed by blood gas analysis. Rapid availability of results is important to help guide changes to ventilator settings. Arterial sampling remains the most accurate method of assessing response to ventilation. Alternative sampling methods include capillary samples which may cause less patient discomfort.[7] Venous samples have also been shown to provide an accurate measure of response to ventilation but do not give useful information on oxygenation.[8]

Arterial sampling was almost universally used to assess response to treatment (160/165; 97.0%). Table 2.2 illustrates that just over a third of hospitals (56/165; 33.9%) used capillary sampling and 37/165 (22.4%) used venous blood gas analysis.

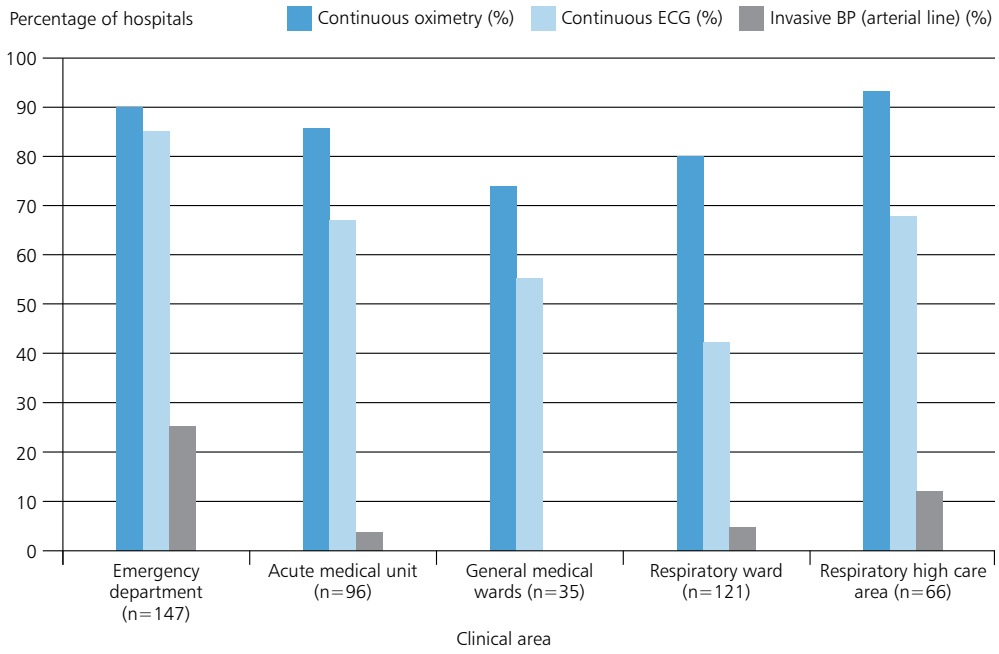

Figure 2.5 Availability of monitoring in different clinical areas

Table 2.2 Blood gas sampling used to assess response to ventilation

	Number of hospitals	%
Arterial	160	97.0
Capillary	56	33.9
Venous	37	22.4
Subtotal	**165**	
Not answered	3	
Total	**168**	

Answers may be multiple for 165 hospitals

Just over a quarter of hospitals where NIV was used, did not have a co-located blood gas machine (44/162; 27.2%) (Table 2.3). It is important in such units that blood gas results are available within a suitable time frame to ensure appropriate changes are made to ventilation.

Bed numbers and staffing

As already noted, NIV services are organised differently in different hospitals. It is important to have adequate capacity to deliver treatment to patients when they need it. This includes a bed base staffed well enough to monitor patients and to deliver effective NIV.

Table 2.3 Dedicated blood gas machine in designated NIV unit

	Number of hospitals	%
Yes	118	72.8
No	44	27.2
Subtotal	**162**	
Not answered	6	
Total	**168**	

Table 2.4 shows the number of beds in the different clinical areas where NIV was delivered. In hospitals that had arrangements for "respiratory high care", they had an average of six beds.

It is recommended that NIV services have "trained and experienced staff available to support the service on a 24/7 basis".[6] Patients who are treated with acute NIV are seriously ill with complex problems and require enhanced nursing care. A staffing ratio of one nurse to two NIV patients for at least the first 24 hours of treatment is recommended.[6]

Table 2.5 shows that just under half of hospitals (79/162; 48.8%) had a defined ratio of nurses to NIV patients as recommended.

Table 2.4 Number of beds in different clinical areas where NIV was delivered

	Clinical area			
Beds	**ICU**	**HDU**	**Respiratory high care**	**Respiratory ward**
Mean	11.8	7.9	6.4	27.1
Median	9	6	6	27
Mode	6	6	4	28
Range	2-50	2-51	2-26	1-64
Total	**113**	**98**	**66**	**100**

Table 2.5 Defined ratio of nurses for patients receiving NIV

	Number of hospitals	%
Yes	79	48.8
No	83	51.2
Subtotal	**162**	
Not answered	6	
Total	**168**	

In the 73 hospitals that reported a defined staffing ratio, the majority (53/73) used a ratio of one nurse to two patients (or better). In 17/73 however the ratio was one nurse to three or more patients (data not shown).

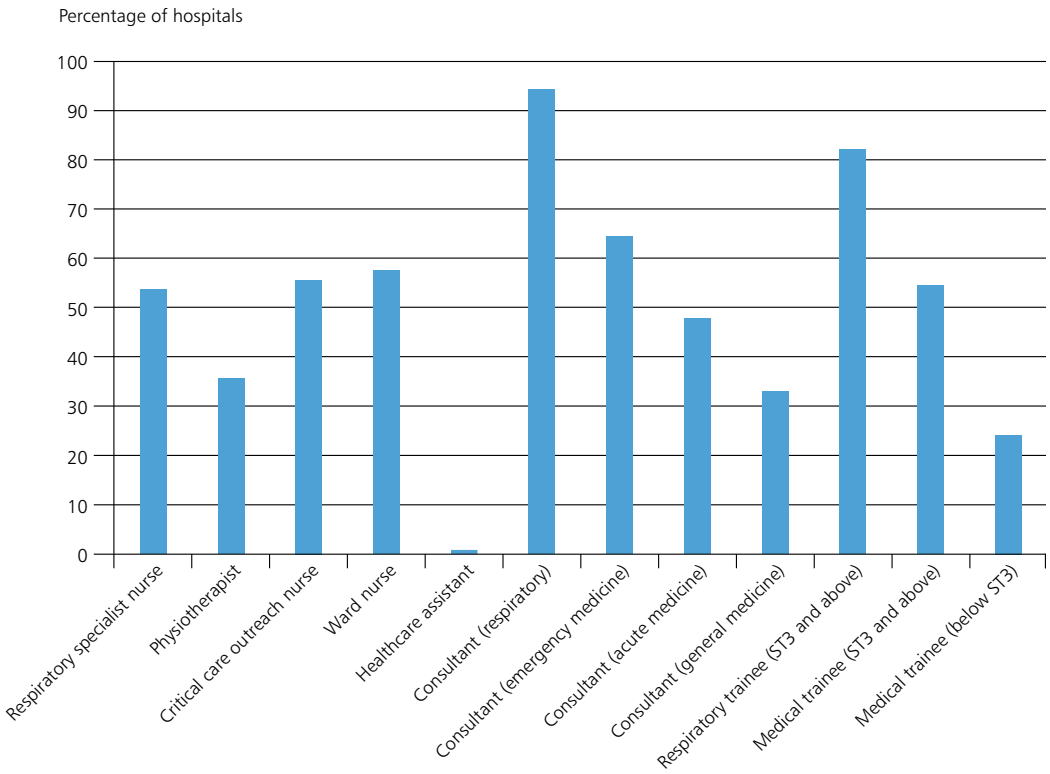

Figure 2.6 Specialties and grades of those who changed ventilator settings

Delivery of NIV service

Figure 2.6 shows that staff from a variety of professional groups and at different grades made changes to ventilator settings.

Figure 2.7 shows who took responsibility for arterial blood gas sampling divided into the same grades and professional groups.

Changes to ventilator settings were most commonly the role of respiratory consultants and senior trainees. In more than one in five hospitals it was reported that medical trainees below the ST3 grade made changes to ventilator settings. More than a half of hospitals had a model of care where ward nurses changed the settings and in more than a third, physiotherapists took on this responsibility.

Arterial blood gas testing was more reliant on junior medical staff. This has implications for service delivery. The team delivering care at the bedside needs to have the skills to monitor the patient's response to treatment and the ability to make changes to ventilation when needed. Medical issues often dictate ventilator management. Good communication within the multi-professional team is therefore essential to ensure the best treatment is delivered to the patient.

While it is important to note that there are a variety of models for ventilator management in place, all of these may be appropriate if the staff involved have had the necessary training and gained the required competency to monitor patients and make changes to ventilator settings.

The BTS guidelines state that annual training should be provided to staff and that they should have competence in delivery of NIV.[6] Most hospitals (140/157; 89.2%) reported that they ran a training programme for staff in NIV (Table 2.6).

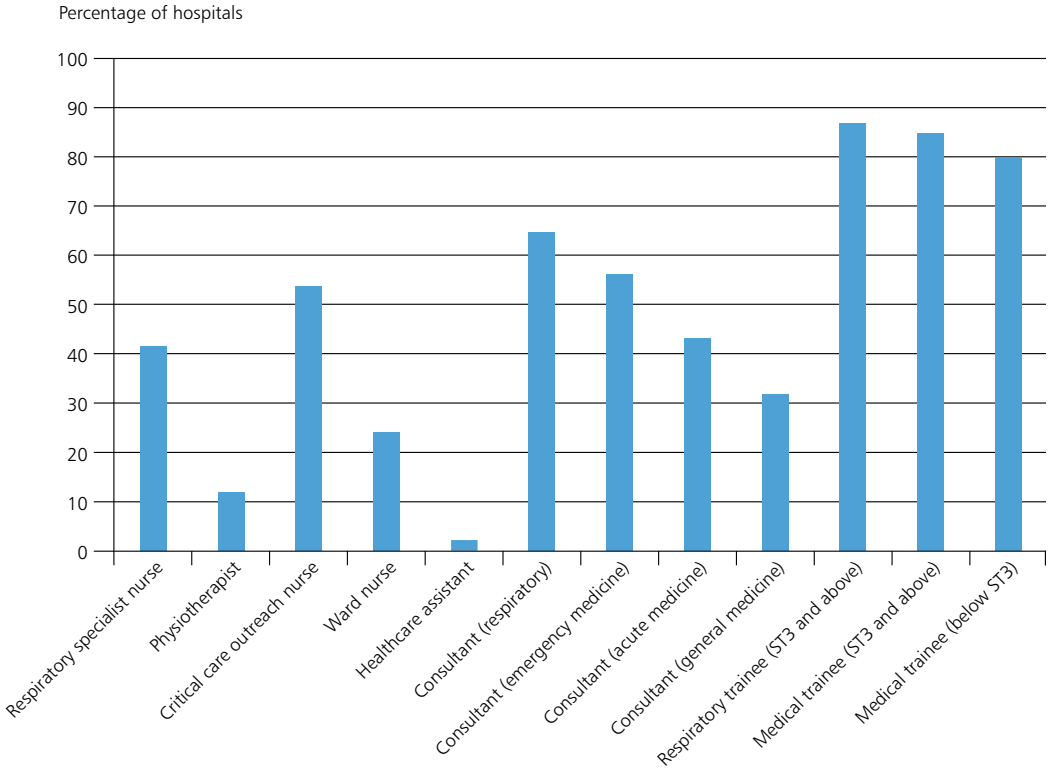

Figure 2.7 Specialties and grades who took arterial blood gas samples

Table 2.6 A training program for NIV is run by the hospital

	Number of hospitals	%
Yes	140	89.2
No	17	10.8
Subtotal	**157**	
Not answered	11	
Total	**168**	

Table 2.7 Staff competency assessment for delivery of NIV

	Number of hospitals	%
Yes	126	81.8
No	28	18.2
Subtotal	**154**	
Not answered	14	
Total	**168**	

The frequency of training for various staff groups is shown for 140 hospitals in Figure 2.8 overleaf. This shows that regular training was reported as taking place at least annually and generally more frequently for all staff groups. There is therefore the opportunity for staff to receive annual training in line with recommended practice.

There were 81.8% (126/154) of hospitals that reported a staff competency assessment for the delivery of NIV (Table 2.7). However Table 2.8 overleaf shows that over a third of these hospitals allowed staff without this competency to supervise patients on NIV directly (42/111; 37.8%). Overall, this means that when hospitals where there was no staff competency are included, 70/154 (45.4%) hospitals had staff without a defined competency who supervised these patients.

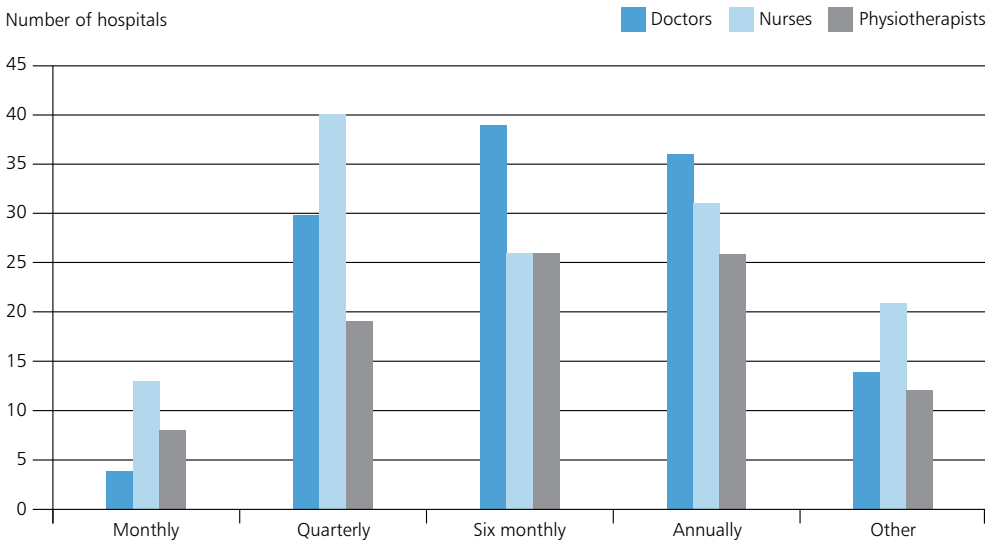

Figure 2.8 Frequency of NIV training courses by specialty

Table 2.8 Staff without competency directly supervise NIV patients

	Number of hospitals	%
Yes	42	37.8
No	69	62.2
Subtotal	**111**	
Not answered	15	
Total	**126**	

Table 2.9 Identified clinical lead for NIV service

	Number of hospitals	%
Yes	144	86.7
No	22	13.3
Subtotal	**166**	
Not answered	2	
Total	**168**	

Service leads

Most (144/166; 86.7%) hospitals had a named medical clinical lead for their NIV service as recommended (Table 2.9).[6] This individual was usually a respiratory consultant (138/140). In 110/133 (82.7%) hospitals, the lead consultant had no specific time allocated in their job plan to lead the service.

Lead roles provided by other professional groups were much less commonly held, being in place in just over half (92/157; 58.6%) of hospitals (Table 2.10). Most of these were nursing leads 69/92, with the remainder (23/92) being physiotherapists.

NIV equipment

The number of ventilators available to run a service is important as it needs to account for peaks in the number of patients requiring treatment. The number of patients, and of ventilators will vary depending on the size of the hospital.

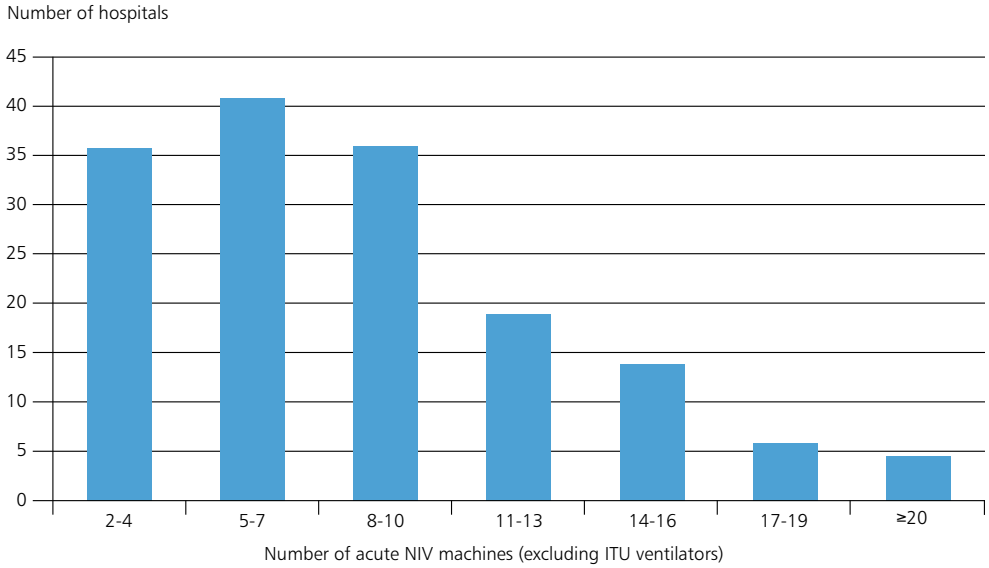

Figure 2.9 Number of acute NIV machines per hospital

Table 2.10 Non-medical lead for NIV

	Number of hospitals	%
Yes – Nursing	69	43.9
Yes – Physiotherapy	23	14.6
No	65	41.4
Subtotal	**157**	
Not answered	11	
Total	**168**	

Figure 2.9 shows the number of acute NIV ventilators for 157 hospitals. In 113/157 (72.0%) hospitals between 2 and 10 ventilators were available to run the NIV service.

The fit of the mask is a key factor in patient comfort, compliance and to reduce leaks of inspired gas. Access to a choice of mask type and size is therefore important in the success of NIV and has been previously recommended.[6] There were 117/163 (71.8%) hospitals that reported offering a choice of mask (data not shown). Masks are generally manufactured in small, medium and large sizes. Most (153/159; 96.2%) hospitals offered three (123 hospitals) or more (30 hospitals) mask sizes (data not shown). (See Appendix 2).

NIV guidelines

As recommended in the BTS 2008 guideline, most (160/165; 97.0%) hospitals had a local guideline or protocol for the provision of NIV (data not shown) and the contents of these appeared to be consistent. Over 90% of local guidelines listed indications, contraindications and a recommendation to make an escalation plan when initiating NIV treatment. A protocol or guidance on weaning from ventilation was included in 116/160 (72.5%) hospitals (Table 2.11).

Table 2.11 Hospital NIV guidelines

	Number of hospitals	%
Indications	150	93.8
Locations where NIV can be provided	146	91.3
Weaning guidance/protocol	116	72.5
Recommendation to make escalation plan	154	96.3
Contraindications to NIV	150	93.8
Total	**168**	

Answers may be multiple

Use of a prescription form and standard observation chart improve reliability of patient treatment and monitoring. These were recommended and examples were included in the BTS guidelines in 2008.[6]

Table 2.12 NIV prescription form

	Number of hospitals	%
Yes	114	68.7
No	52	31.3
Subtotal	**166**	
Not answered	2	
Total	**168**	

Table 2.13 Specific NIV observation chart

	Number of hospitals	%
Yes	136	83.4
No	27	16.6
Subtotal	**163**	
Not answered	5	
Total	**168**	

Over two thirds (114/166; 68.7%) of hospitals had a prescription form for NIV and more than four out of five (136/163; 83.4%) used an observation chart specifically for use with NIV (Tables 2.12 and 2.13). The observation charts consistently listed pressure settings, oxygen administration and saturation and respiratory rate which were included in the example documents recommended within the guidelines. (Table 2.14).

For the 52 hospitals without a prescription form and the 27 without a specific observation chart, introduction of these documents represents an opportunity to improve care (Appendix 1).

Home NIV services

Finally, patients receiving NIV represent a complex group, an increasing proportion of whom are candidates for long term overnight ventilation support at home. Discharge from hospital is sometimes delayed while patients wait for home NIV to be arranged. In some cases this requires transfer to another hospital. Of the hospitals who responded to the organisational questionnaire 78/168 (46.4%) hospitals did not run a home NIV service.

Table 2.14 Availability of an NIV observation chart

	Yes	No	Subtotal	Not answered	Total
Ventilation mode	106	28	**134**	4	**138**
Inspiratory positive airway pressure setting	136	0	**136**	2	**138**
Expiratory positive airway pressure setting	134	0	**134**	4	**138**
Oxygen flow rate/concentration	127	4	**131**	7	**138**
Oxygen saturation	125	7	**132**	6	**138**
Respiratory rate	118	14	**132**	6	**138**
Conscious level	88	31	**119**	19	**138**

Key Findings

- 39/165 hospitals routinely collected data on the number of NIV episodes in their hospital
- In 23.4% (37/158) of hospitals, NIV services were covered out of hours by a respiratory consultant all of the time
- In 75.3% (119/158) of hospitals respiratory consultants provided cover for 50% or less of the out of hours time period and in 15 hospitals there was no out of hours cover provided by a respiratory consultant
- Continuous oxygen saturation monitoring was only available on 98/121 respiratory wards, 26/35 general medical wards, where NIV was used, and on 61/66 respiratory high care wards
- Continuous ECG monitoring was available in 68/96 acute medical units and 44/66 respiratory high care areas
- Just under half of hospitals (79/162; 48.8%) had a defined ratio of nurses to NIV patients as recommended by this BTS
- 144/166 (86.7%) hospitals had a named medical clinical lead for their NIV service. This was usually a respiratory consultant (138/140). In 110 hospitals, the lead consultant had no specific time allocated in their job plan to lead the service
- 160/165 (97.0%) hospitals had a local guideline or protocol for the provision of NIV
- Over 90% of local guidelines listed indications, contraindications and a recommendation to make an escalation plan when initiating NIV treatment
- 114/166 (68.7%) hospitals had a prescription form for NIV
- 136/163 (83.4%) hospitals used an observation chart specifically for use with NIV
- 70/154 (45.4%) hospitals had staff without a defined competency who supervised patients receiving NIV.

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3

Sample population

The patient age distribution in this study ranged from 26 to 98 with the majority of patients aged between 61 and 90. Of these 43.1% (186/432) were male and 56.9% (246/432) were female. The breakdown of age demographics by gender is shown in Figure 3.1. The average age was 71.1 years for male and 72.3 years for female patients.

The majority of patients were admitted via the emergency department (343/421; 81.5%), with 270 of these patients arriving by ambulance. Of the remaining admissions, 55 patients were referred by their General Practitioner and four were admitted from an outpatient clinic.

As would be expected for a group of patients who were admitted mainly as an emergency, admissions were distributed evenly across all days of the week (data not shown).

Admission diagnosis / indication for NIV

The study period covered the same two months as the BTS audit period (1st February – 31st March 2015).The main diagnostic groups receiving NIV in this study were similar to those in the most recent BTS audit. These were chronic obstructive pulmonary disease (COPD) (288/417; 69.1% - BTS 70%), cardiogenic pulmonary oedema (60/417; 14.4% - BTS 9.6%), obesity/hypoventilation syndrome (39/417; 9.4% - BTS 8.6%), and chest wall/neuromuscular disease (15/417; 3.6% - BTS 4.8%).

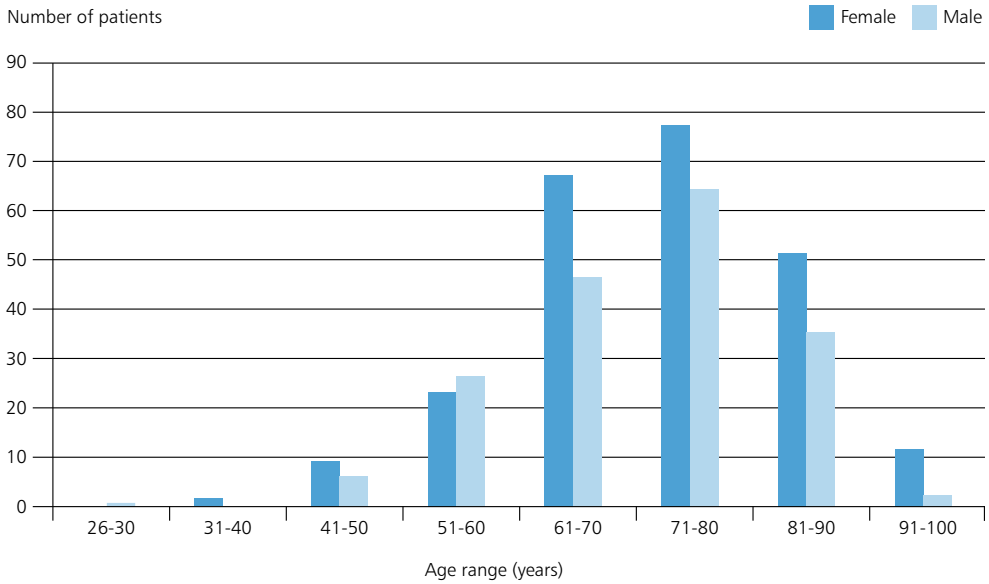

Figure 3.1 Age and gender

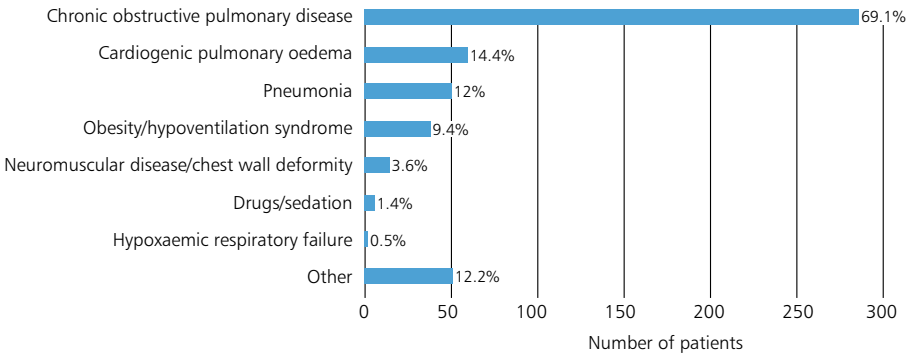

Figure 3.2 Indication for NIV during the study time period; n=417

Figure 3.2 shows that the indications for NIV in this study. Importantly, there was a group of 50 patients (12%) where the primary indication for NIV was pneumonia.

Patients who have previously been treated with NIV are more likely to have a successful outcome if they require acute NIV treatment again. There were 60/300 (20%) cases where the patient had been ventilated previously for the same indication.

Tobacco smoking

As would be expected in a patient group with a high incidence of COPD, where a smoking history was recorded, the majority of patients were either current or ex-smokers. Of the patients with COPD, 269/276 (97.5%) were current or ex-smokers. In the 127 patients with non-COPD diagnoses, and a documented smoking history, 23 (18%) were current smokers (Table 3.1). This is in line with the current UK adult smoking rates of 19%.[9]

Table 3.1 Smoking history – clinician questionnaire

	COPD		Non-COPD	
	Number of patients	**%**	**Number of patients**	**%**
Ex smoker	148	53.6	53	41.7
Current smoker (around the time of admission)	121	43.8	23	18.1
Never smoked	7	2.5	51	40.2
Subtotal	**276**		**127**	
Unknown/not answered	10		19	
Total	**286**		**146**	

Table 3.2 Indication for NIV (this episode) for patients who had never smoked

	Number of patients
Cardiogenic pulmonary oedema	17
Obesity/hypoventilation syndrome	14
Pneumonia	10
Other including chest wall deformity	10
Chronic obstructive pulmonary disease	7
Neuromuscular disease	7
Not documented	3

Answers may be multiple; n=58

Amongst the group of 403 patients in whom smoking history was documented, only 58 (14.4%) had never smoked and 144 (35.7%) were current smokers.

Table 3.2 shows the indication for NIV in the group of 58 patients who had never smoked. The most common indications in this group were cardiogenic pulmonary oedema and obesity hypoventilation syndrome.

Lung function

In COPD, the degree of lung function impairment measured by forced expiratory volume in one second (FEV_1) has a direct relationship to mortality. Lung function results were available for 162 patients, of whom 129 had underlying COPD. The mean values for forced expiratory volume in one second (FEV_1) are shown in Table 3.3.

Figure 3.3 shows the lung function for the 129 patients with COPD where this was recorded.

Table 3.3 Mean values for forced expiratory volume in one second (FEV_1)

FEV_1 (litres)	All patients	COPD
Mean	0.95	0.84
Standard deviation	0.51	0.39
Standard error of the mean	0.04	0.03

Co-morbidities

Co-morbidity was common, occurring in 389/432 patients on admission (Table 3.4). The most common co-morbidities were hypertension and cardiovascular disease which are both associated with cigarette smoking and increasing age. More than half of the total group (53.1%) had two or more co-morbid conditions.

Table 3.4 Number of known comorbidities at time of admission

	Number of patients	%
None	43	9.9
1 comorbidity	160	37.0
2 comorbidities	116	26.9
3 or more comorbidities	113	26.2
Total	**432**	

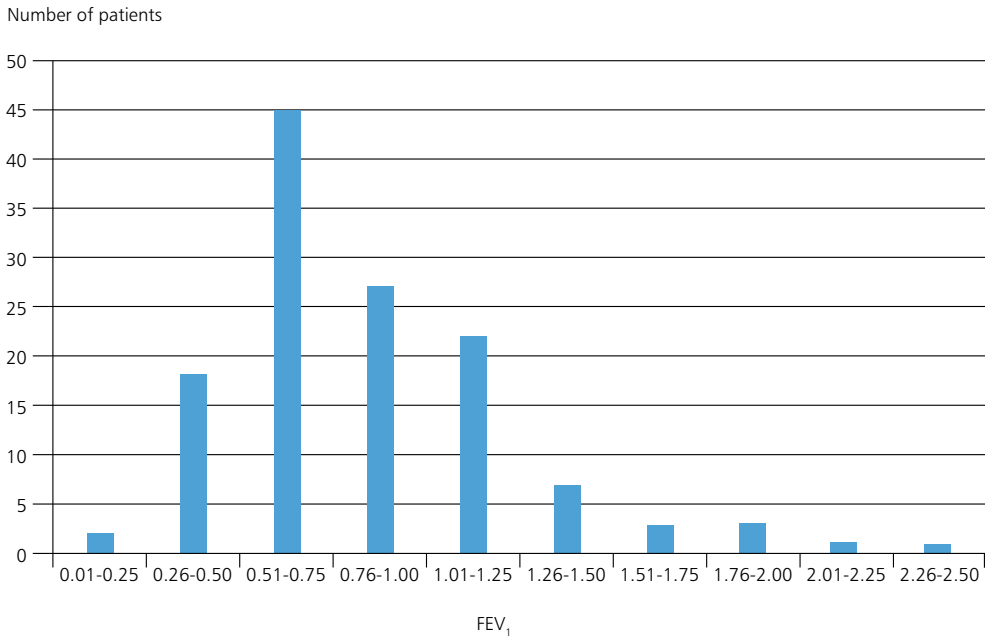

Figure 3.3 The lung function for patients with COPD; n=129

Body Mass Index

According to national estimates two thirds of adults are overweight or obese and by 2034, 70% of adults are expected to be overweight or obese. The patient's body mass index (BMI) was documented in 200 cases. The average BMI was 27.4 and 108 (54%) of these patients had a BMI greater than 24.9 (Figure 3.4). The primary indication for NIV was obesity hypoventilation in 39 (9.4%) cases reviewed. The BMI was available for 20 of these patients and the average BMI of this group was 39.3.

Clinical frailty – Rockwood scale

Clinical frailty is increasingly recognised as a syndrome associated with poor clinical outcomes and has been shown to be an independent predictor of in-patient mortality.[10] The Clinical Frailty Scale (Appendix 3) is a practical and widely used tool for assessing frailty. Both the clinicians at the hospital and reviewers were asked to assess frailty using this scale when reviewing the case notes. The clinicians were able to estimate a Rockwood clinical frailty score for 426/432 patients. In patients with a Rockwood score assessed by both a clinician and a reviewer, 215/306 (70.3%) were given the same score and the score differed by more than one in only 27/306 (8.8%) cases. This confirms that the Rockwood score provides a consistent assessment of frailty in a large group of patients.

The majority of patients were moderately or severely frail (Figure 3.5). Therefore the combination of frailty and co-morbidity describes a particularly vulnerable patient group. There was no difference in degree of frailty between the total population studied and those with COPD. Of the total study population 1.6% (7/426) were assessed as being terminally ill.

Further data on frailty and overall outcome is presented in Chapters 6,7 & 9.

Underlying level of breathlessness

Underlying breathlessness can be measured by the Modified Medical Research Council (MMRC) Dyspnoea Scale[11] (Appendix 3). Worse degrees of breathlessness are associated with worse outcomes. The underlying level of breathlessness prior to the illness causing the admission was documented using the MMRC scale in 41 patients. Where

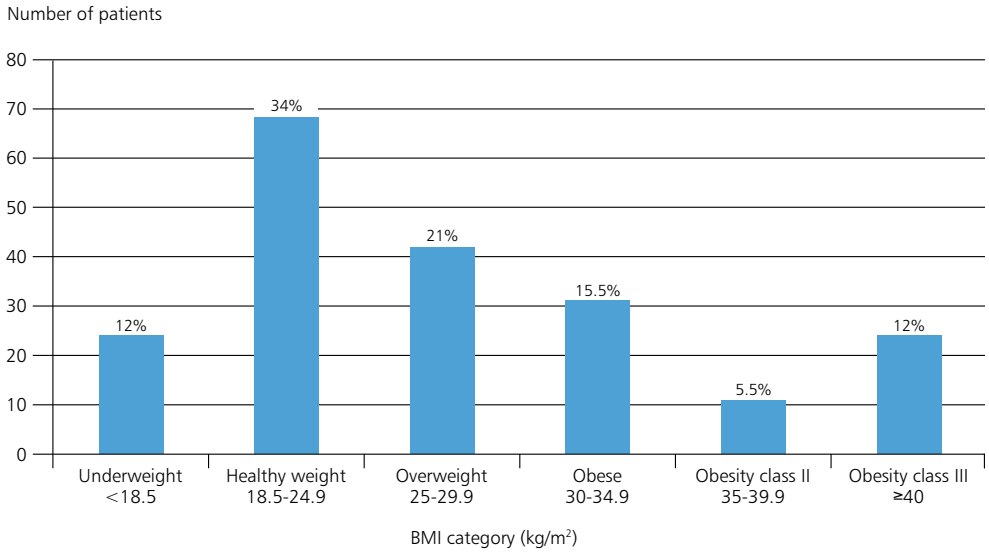

Figure 3.4 Body Mass Index; n=200

this was not originally documented, clinicians were asked to estimate the MMRC score. They were able to do this in a further 242/391 cases. Over three quarters (216/283; 76.3%) of the patients for which it was assessed, had a MMRC dyspnoea score of 3 or 4 which reflects breathlessness on exertion on mobilising 100 metres or less (Figure 3.6).

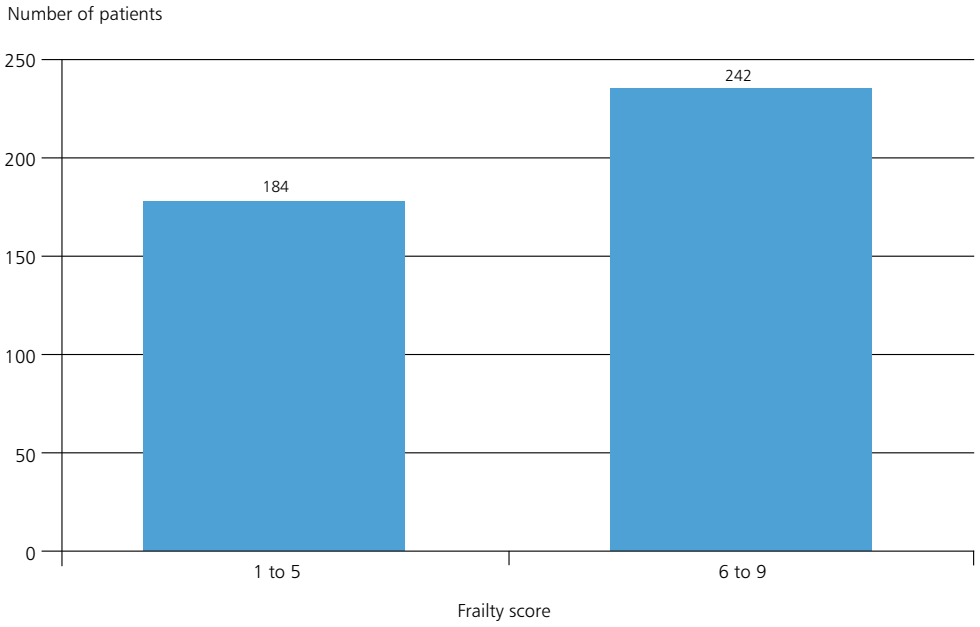

Figure 3.5 Rockwood clinical frailty score - clinical frailty of all patients studied on admission; n=426 Score of 6 or more means moderately or severely frail

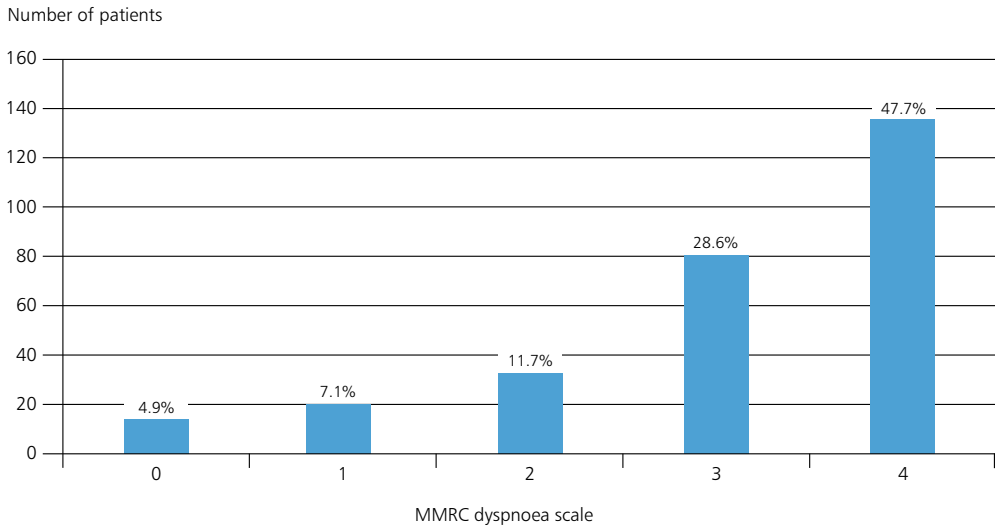

Figure 3.6 MMRC breathlessness score; n=283

Key Findings

- The majority of patients were admitted via the emergency department (343/421; 81.5%)
- 69.1% (288/417) of patients were admitted with COPD
- 14.4% (60/417) of patients were admitted with cardiogenic pulmonary oedema
- 50 patients (12%) were admitted where the primary indication for NIV was pneumonia
- 60/300 (20%) of patients had been ventilated previously for the same indication
- The majority of patients were moderately (32.9%) or severely (18.8%) frail
- Over three quarters (216/283; 76.3%) of the patients for which it was assessed, had a MMRC dyspnoea score of 3 or 4 which reflects breathlessness on exertion on mobilising 100 meters or less.

4

Initial management

Vital signs at initial triage

Physiological track and trigger systems have been recommended for use in all acute areas (NICE and NCEPOD).[12,13] The National Early Warning Score (NEWS) was introduced by the Royal College of Physicians of London in 2012 as the recommended track and trigger system (See Appendix 4).[14]

NEWS allocates a higher number of points the more a physiological parameter varies from the normal range. It has been validated in hospital patients and higher scores predict a group of patients with a higher risk of death. This system has built in recommendations for the frequency of vital signs monitoring. For patients with a score of 5 or more, hourly or more frequent monitoring is recommended. A respiratory rate of 25 or above scores three points on the NEWS and this is also used as a trigger threshold for at least hourly vital signs monitoring. A respiratory rate of 25 or more is also included in current NIV guidelines as a 'red flag' which suggests an increased risk of NIV failure and where clinical review should take place with consideration given to the use of invasive ventilation.[7]

Escalation and clinical review is built into the NEWS system, a score of 5-6 requires urgent review by a doctor or acute team nurse. For patients with a score of 7 or more NEWS recommends emergency assessment by a team with critical care competencies and "*usually transfer of the patient to a higher dependency care area*". NEWS levels of "*Three: Threat, Six: Sick, Nine: Now*" have been suggested as an aide memoire to prompt escalation and have been used in the analysis that follows.

Early warning scores were not consistently documented in the study population. They were not used in 159/338 (47%) cases. This means that in at least 36.8% of the total study population (159/432), an early warning score was not used as part of the initial assessment.

In patients where an early warning score was used, the majority (101/179; 56.4%) of patients had a score of 6 or more indicating the need for urgent clinical assessment. At initial triage, the score was 9 or more in 31/179 (17.3%) patients, suggesting the need for critical care assessment (Figure 4.1).

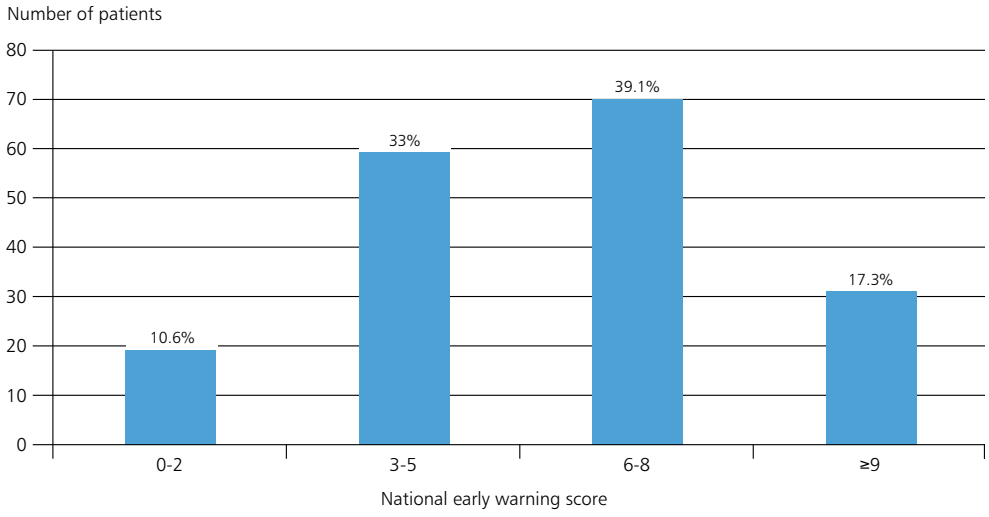

Figure 4.1 Initial early warning score; n=179

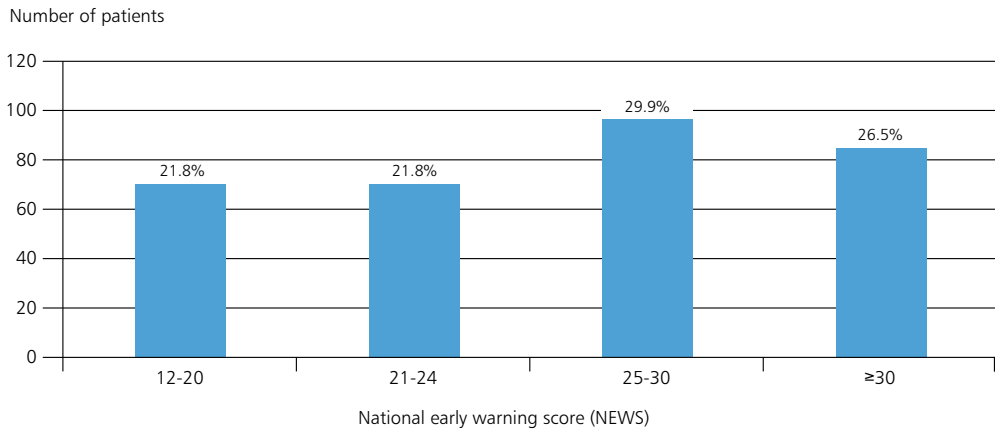

Figure 4.2 Initial triage observation - respiratory rate; n=321

A respiratory rate of 12-20 breaths per minute is normal, and scores no points. At the time of initial assessment within the Emergency Department, respiratory rate was documented in 321 cases. Of these 78.2% (251/321) of patients had a respiratory rate of more than 20. The initial respiratory rate was 25 or more in 181/321 (56.4%) patients (Figure 4.2)

These data show that this is a group of patients that requires rapid assessment and frequent monitoring. This can often be identified as soon as they are assessed in hospital.

Initial oxygen treatment

A slight elevation in carbon dioxide (CO_2) levels generally stimulates breathing which in turn keeps the level of carbon dioxide in the normal range. Some patients with chronic lung disease have chronically elevated carbon dioxide levels and depend on a lower level of oxygen in the blood to drive breathing. These patients are vulnerable to the effects of high concentrations of oxygen as they lead to reduced ventilatory drive and a further rise in carbon dioxide level. As a result, controlled oxygen therapy is recommended, maintaining an oxygen saturation of 88-92% to prevent this complication.[15] Delivery of controlled oxygen requires the use of a Venturi mask.

On admission to hospital, oxygen administration is common to maintain safety for patients at a critical point in their illness. The use of oxygen to save life therefore has to be balanced against the risk of oxygen toxicity in patients with chronic lung disease. Oxygen alert cards have been promoted for patients with lung disease vulnerable to the effects of excess oxygen administration as one way of emphasising the need for caution with oxygen therapy in COPD.[16]

Previous data has shown that COPD patients are frequently treated with high concentrations of oxygen both prior to hospital admission and during initial hospital treatment and this is associated with higher mortality rates.[17] The most recent BTS audit suggested that oxygen toxicity contributed to hypercapnia in 17% of cases.[3]

In this study, there were 84/312 (26.9%) peer reviewed cases where the case reviewers found that oxygen toxicity contributed to the hypercapnia. The clinicians in their own hospitals considered that oxygen toxicity contributed to hypercapnia in 95/420 (22.6%) patients (Table 4.1).

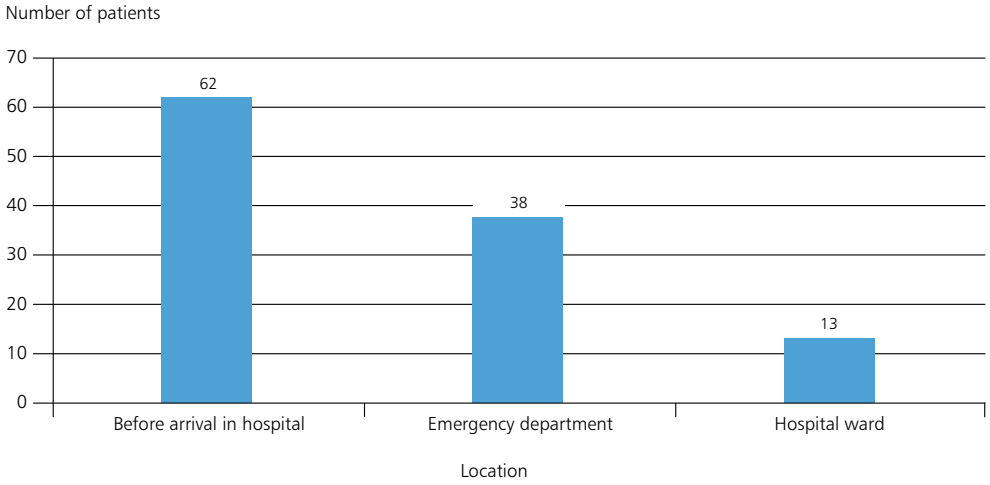

Figure 4.3 Location where excess oxygen was administered – clinician questionnaire
Answers may be multiple; n=91

Figure 4.3 shows that the clinicians in their own hospital considered that excess oxygen was most commonly administered before arrival in hospital (62 cases). There were 38 cases where excess oxygen was administered in the Emergency Department.

Table 4.1 Oxygen toxicity contributed to hypercapnia

	Reviewers' opinion	%	Clinicians' opinion	%
	Number of patients		Number of patients	
Yes	84	26.9	95	22.6
No	228	73.1	325	77.4
Subtotal	**312**		**420**	
Unknown	41		12	
Total	**353**		**432**	

Table 4.2 Appropriateness of oxygen administered in the emergency department – reviewers' opinion

	Number of patients	%
Yes	157	67.7
No	75	32.3
Subtotal	**232**	
Unknown	70	
Total	**302**	

In almost a third of cases (75/232; 32.3%) the reviewers found that oxygen was not administered appropriately in the emergency department (Table 4.2).

Of the 353 cases peer reviewed, there were 96 where there was no documentation available about oxygen therapy prior to arrival in hospital. Of the remaining cases, 186/257 (72.4%) patients were treated with oxygen prior to their admission to hospital (data not shown).

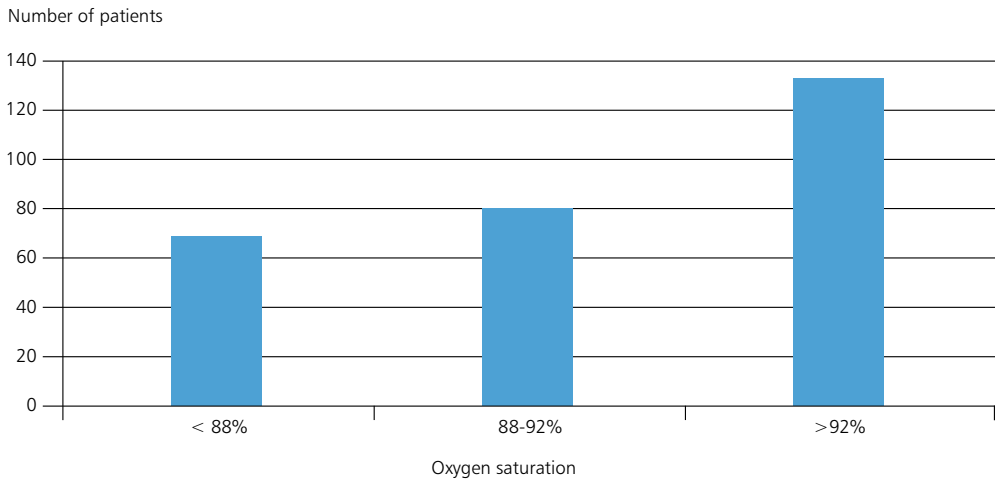

Figure 4.4 Range of oxygen saturation at triage; n=283

The oxygen saturation at the time of initial triage was recorded for 283 patients. In 81 (28.6%) patients it was in the recommended range of 88-92%. The value measured was below the recommended range in 69 (24.4%) and higher than recommended in 133 (47%) (Figure 4.4).

In the emergency department, the method of oxygen administration was not documented in 190/346 cases reviewed. For the cases where it was recorded, the most common method of administration was with nasal cannulae. Of the 158 patients with an oxygen delivery device recorded, a venturi mask was used in only 27 (17.1%).

Table 4.3 Oxygen delivery device in the emergency department

	Number of patients
Nasal cannulae	86
Non-rebreathe device	35
Venturi mask	27
Nebuliser	10
Air	32
Not documented	190
Total	**380**

The above data emphasises how common oxygen toxicity is and the importance of using controlled oxygen in at risk patients.

Consultant review

All medical patients newly admitted to hospital should be seen by a competent clinical decision maker within 4 hours of arrival and have a full assessment and appropriate management plan documented.[18] They should also be reviewed by a consultant within a maximum of 14 hours.[9]

First consultant review was documented in 410 cases. Table 4.4 shows that in 98 (23.9%) patients this review was by a respiratory consultant. In 97 (23.7%) it was by a consultant in acute medicine.

Table 4.4 Specialty of first consultant review

	Number of patients	%
Respiratory medicine	98	23.9
Acute medicine	97	23.7
General medicine	78	19.0
Critical/intensive care medicine	32	7.8
Geriatric medicine	27	6.6
Gastroenterology	17	4.1
Cardiology	16	3.9
Endocrinology	14	3.4
Other	31	7.6
Subtotal	**410**	
Unanswered	22	
Total	**432**	

Reviewers found that in one in eight cases (40/320; 12.5%), the timing of the initial consultant review was not appropriate (Table 4.5).

Table 4.5 Appropriate timing of the consultant review – reviewers' opinion

	Number of patients	%
Yes	280	87.5
No	40	12.5
Subtotal	**320**	
Not answered	33	
Total	**353**	

Reviewers also assessed the initial management plan. In 23/347 (6.6%) sets of notes there was no clear management plan (Table 4.6) and where there was this was not appropriate in 27/295 (9.2%) (Table 4.7). In total therefore 50/347 (14.4%) patients either had no clear initial management plan or an inappropriate one.

Table 4.6 Clear initial management plan – reviewers' opinion

	Number of patients	%
Yes	324	93.4
No	23	6.6
Subtotal	**347**	
Not answered	6	
Total	**353**	

Table 4.7 Appropriate initial management plan – reviewers' opinion

	Number of patients	%
Yes	268	90.8
No	27	9.2
Subtotal	**295**	
Not answered	29	
Total	**324**	

Key Findings

- First consultant review was documented in 410 cases. In 98 (23.9%) patients this review was by a respiratory consultant. In 97 (23.7%) it was by a consultant in acute medicine
- Early warning scores were not used in 159/338 (47%) cases
- In patients where an early warning score was used, the majority (101/179; 56.4%) of patients had a score of 6 or more indicating the need for urgent clinical assessment
- There were 84/312 (26.9%) peer reviewed cases where the case reviewers found that oxygen toxicity contributed to the hypercapnia
- Only 81/283 (28.6%) patients had an oxygen saturation level within the recommended target range of 88-92%
- Of the 158 patients with an oxygen delivery device recorded, a venturi mask was used in only 27 (17.1%)
- In total 50/347 (14.4%) patients either had no clear initial management plan or an inappropriate one.

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Medical management and treatment prior to NIV being started

Non-invasive ventilation (NIV) is often needed soon after admission to hospital. In this study, the time between admission (emergency department triage) and start of NIV was known in 242 patients. For 71 of these patients, NIV was started more than 24 hours after admission. Time to starting NIV is shown in Figure 5.1 for the remaining 171 patients. NIV was started within four hours in 116 patients, within 8 hours in 140 and within 12 hours in 154.

In 143/302 (47.4%) cases reviewed, NIV was started before the first consultant review. In the remaining 159 cases, NIV treatment was started after the first review had taken place.

Table 5.1 shows that reviewers found that in nearly a fifth of cases treatment with NIV was not an appropriate intervention (66/351; 18.8%). In this group, 42 out of 66 patients died.

Table 5.1 Appropriateness of NIV as an intervention – reviewers' opinion

	Number of patients	%
Yes	285	81.2
No	66	18.8
Subtotal	**351**	
Not answered	2	
Total	**353**	

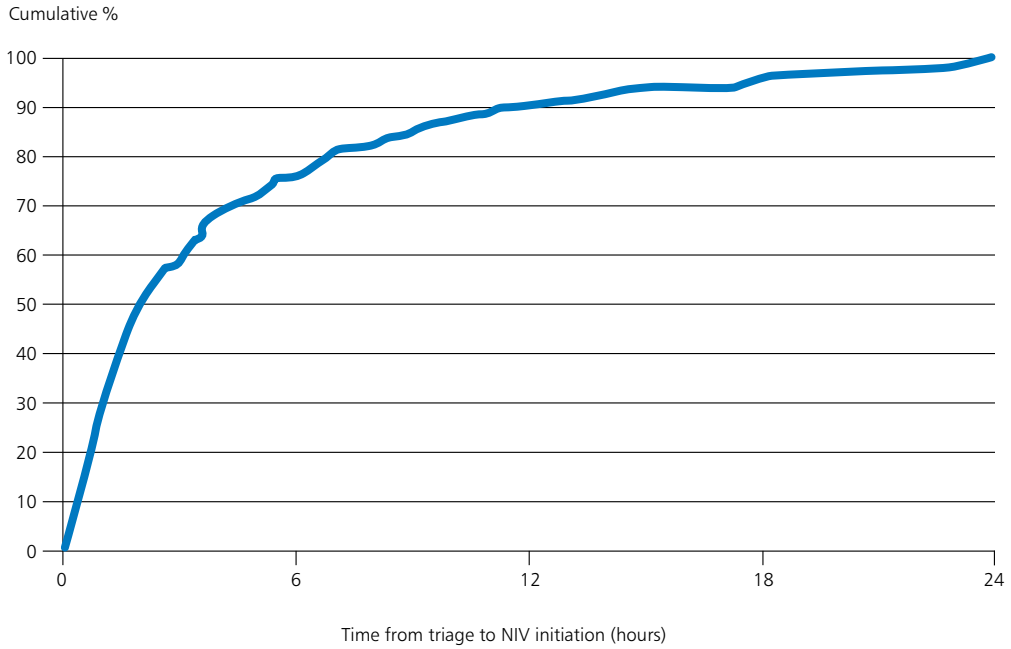

Figure 5.1 Time from triage to NIV initiation in the first 24 hours; n=171

Poor decision making about NIV use occurred for a variety of reasons. In 27 of the cases assessed, the patient had advanced or terminal illness where NIV was not indicated and a palliative approach would have been more appropriate.

There were also 17 cases where intubation and ventilation in intensive care was considered by reviewers to be more appropriate than treatment with NIV.

In 11 patients NIV was started before medical management had been in place long enough to work, which might have meant that NIV could have been avoided. In five patients NIV was used inappropriately for hypoxaemic, not hypercapnic respiratory failure and a further five patients had metabolic, not respiratory acidosis.

For the patients where NIV was felt to be inappropriate and where the speciality of the doctor who initiated the NIV episode was documented, Figure 5.2 shows that NIV was mostly used appropriately when it was initiated by a respiratory specialist (4/49 cases inappropriate).

For patients who required intubation and ventilation rather than NIV, the reviewing specialist was most often from intensive care. In the cases where NIV was initiated by intensive care doctors, there were 15/40 patients where NIV was considered inappropriate (data not shown).The reason for this judgement in these cases was that NIV delayed intubation.

Table 5.2 Reasons why the reviewers believed NIV was inappropriate

Hypoxaemia (not hypercapnia)	5
Metabolic acidosis	5
ICU/intubation preferred option	17
Medical management	11
Advanced/terminal illness	27

Answers may be multiple; n=65

CASE STUDY 1

An elderly patient with advanced metastatic lung cancer was admitted to hospital with pneumonia and treated with antibiotics and oxygen. On the fifth night after admission they deteriorated. A blood gas showed ventilatory failure. They were transferred to the respiratory unit for acute NIV. On review by the respiratory consultant the following morning NIV treatment was felt to be inappropriate. The patient was treated on an end of life pathway and died a few hours later.

The reviewers agreed that starting NIV was inappropriate. Early in the admission, planning for end of life care in the event of deterioration would have been more appropriate.

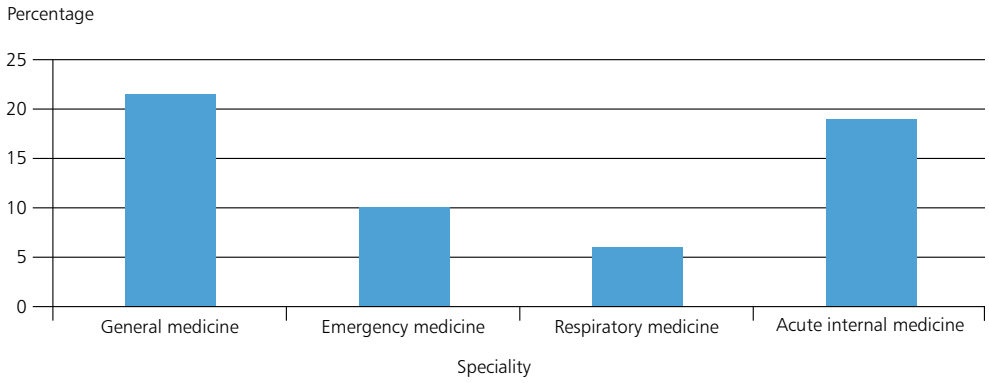

Figure 5.2 Inappropriate NIV by initiating specialty – reviewers' opinion

Table 5.3 Outcome for the patients where NIV was considered inappropriate

	Reason (number of patients who were admitted to critical care)				
Outcome	**Futile**	**Intubation**	**Medical**	**Other**	**Total**
Died in hospital	24	8	4	6	**42**
Discharged alive	3(1)	9 (7)	7 (2)	5 (2)	**24**
Total	**27**	**17**	**11**	**11**	**66**

Table 5.3 shows the outcome for the 66 patients where NIV was considered inappropriate. Of the 27 patients where it was considered that NIV was a futile intervention in a patient with advanced disease; 24 patients died and 3 survived. Of the 11 patients identified where better medical management would have been possible; 4 patients died and 7 survived. And of the 17 patients where it was agreed that intubation in intensive care would have been more appropriate; 8 patients died and 9 patients survived.

When treatment with NIV does not improve hypercapnia and acidosis, there is a high risk of death. Intubation and invasive ventilation in the intensive care unit may be appropriate. In some patients, however, intubation may also be considered an inappropriate intervention.

Guidelines have recommended that prior to starting NIV treatment there should be a plan in place for actions to be taken in the event of treatment failure.[6] No such plan was documented in more than a third of cases (128/352; 36.4%) (Table 5.4).

Table 5.4 Documented plan in event of treatment failure

	Number of patients	%
Yes	224	63.6
No	128	36.4
Subtotal	**352**	
Not answered	1	
Total	**353**	

Where a plan was documented, reviewers considered that the plan was appropriate in 93.6% (204/218) of cases reviewed (Table 5.5).

Table 5.5 Documented plan in event of treatment failure was appropriate – reviewers' opinion

	Number of patients	%
Yes	204	93.6
No	14	6.4
Subtotal	**218**	
Not answered	6	
Total	**224**	

Data from the clinical questionnaire showed that decisions were made about escalation of treatment in 302/432 patients at some point in the admission. Table 5.6 shows that in 183/302 (60.6%) cases, a decision was taken that invasive ventilation was not appropriate. Intubation and ventilation was considered appropriate in 68/302 (22.5%) and no specific decision about invasive ventilation was made in 51/302 (16.9%) cases.

Table 5.6 Escalation decisions

	Number of patients	%
For CPR	67	22.2
Not for CPR	198	65.6
For invasive ventilation	68	22.5
Not for invasive ventilation	183	60.6
For critical care	79	26.2
Not for critical care	137	45.4

Answers may be multiple; n=302

CASE STUDY 2

An elderly patient with dementia was admitted with respiratory failure and pneumonia. They were admitted to the medical ward and started NIV. No escalation plan was documented. The patient was agitated on NIV. After seven hours of ineffective NIV, the patient deteriorated with an elevated early warning score (NEWS 9). The medical emergency team was called. After assessing the situation, the medical registrar discussed palliative care options with the patient's family and NIV was discontinued.

Reviewers considered that NIV was probably inappropriate but that an escalation plan setting clear goals of treatment at the outset would have improved communication and prevented the call to the medical emergency team.

NIV is one of the treatments for ventilatory failure. Other medical treatments are equally important and should be directed at the underlying cause both prior to and alongside the use of NIV. Reversible factors that contribute to the development of acute hypercapnic respiratory failure include uncontrolled oxygen therapy leading to oxygen toxicity, and severe bronchospasm. In some cases, treatment of these factors can prevent the need for NIV. In others, poor non-ventilator management prior to NIV will lead to worsening acidosis, and higher mortality rates.

The treatments used following admission are listed in Figure 5.3. Most patients received a combination of therapies including oxygen, nebulised bronchodilators, antibiotics and corticosteroids.

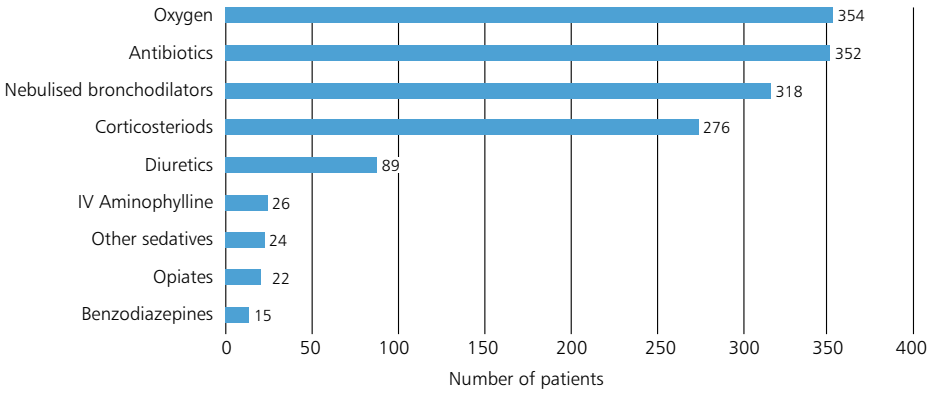

Figure 5.3 Treatments prescribed/administered following admission; n=413

Table 5.7 Non-ventilator management appropriate prior to NIV

	Reviewers' opinion		Clinicians' opinion	
	Number of patients	**%**	**Number of patients**	**%**
Yes	272	77.3	350	82.9
No	80	22.7	72	17.1
Subtotal	**352**		**422**	
Not answered	1		10	
Total	**353**		**432**	

Table 5.7 shows that the reviewers found that in 80/352 (22.7%) cases, non-ventilator management prior to NIV was not appropriate and clinicians who reviewed the case notes in their own hospital found 72/422 (17.1%) cases where there was room for improved non-ventilator management. The areas for improvement that were identified included use of controlled oxygen therapy and better use of bronchodilators.

Table 5.8 Non-ventilator management appropriate – agreement between clinicians and reviewers

	Reviewers' opinion				
Clinicians' opinion	**Yes**	**No**	**Subtotal**	**Not answered**	**Total**
Yes	211	50	261	1	**262**
No	33	20	53	0	**53**
Subtotal	**244**	**70**	**314**	**1**	**315**
Not answered	5	0	5	0	**5**
Total	**249**	**70**	**319**	**1**	**320**

Table 5.8 shows that in the 320 cases where data were available from both the clinical questionnaire and peer review, there were 20 cases where the clinician and the reviewer both identified areas for improved management. In addition there were a further 33 cases identified by the clinician and 50 cases identified by the reviewer where non-ventilator management could have been improved. In total between them, they identified 103/314 (32.8%) cases where non-ventilator management could have been improved.

In the cases where non-ventilator management could have been improved, both reviewers (38/79) and clinicians reviewing their own cases (26/65) thought that with better non-ventilator management, NIV could have been avoided in a substantial proportion of cases (Table 5.9).

Table 5.9 NIV could have been avoided

	Reviewers' opinion	Clinicians' opinion
	Number of patients	**Number of patients**
Yes	38	26
No	41	39
Subtotal	**79**	**65**
Not answered	0	6
Total	**79**	**71**

Medical and specialist review

As already noted in Chapter 2 (organisational data), most NIV services were reported as being based in either critical care areas or on respiratory units. Out of hours, the service was often covered by the general physicians.

There were 58/348 (16.7%) cases where appropriate specialist review was not documented (Table 5.10). In the patients who were reviewed by a specialist, the speciality of the reviewing consultant was respiratory medicine (159/259) or critical care (60/259) in 84.6% (219/259) of cases reviewed (Table 5.11).

Table 5.10 An appropriate specialist review took place

	Number of patients	%
Yes	290	83.3
No	58	16.7
Subtotal	**348**	
Not answered	5	
Total	**353**	

Table 5.11 Specialty of the specialist review

	Number of patients	%
Respiratory medicine	159	61.4
Critical care medicine	60	23.2
Other	14	5.4
General medicine	11	4.2
Cardiology	5	1.9
Acute medicine	5	1.9
Anaesthetics	5	1.9
Subtotal	**259**	
Not documented	31	
Total	**290**	

As previously noted, almost all NIV services were led by the respiratory team and treatment was usually provided on specialist respiratory wards or in critical care units. Data from the clinician questionnaire show that 297/395 (75.2%) patients were reviewed by a respiratory consultant during the admission (Table 5.12). Table 5.12 also lists review by other members of the respiratory specialist team. There were 32 patients who had no review by the specialist respiratory team during the admission.

The time between admission (emergency department triage) and review by a respiratory consultant is shown in Figure 5.4 for 133 patients where this was recorded and where it took place in the first 72 hours. A further 40 patients were seen by a respiratory consultant for the first time more than 72 hour after admission.

CASE STUDY 3

A patient was brought to hospital by ambulance with an exacerbation of COPD. On initial assessment, the patient was wheezy, respiratory rate was 24 and oxygen saturation 98% on a non-rebreathe system. Blood gases revealed pO_2 15.3 kPa, pCO_2 8.2 kPa and pH 7.28. The patient was started on NIV and improved rapidly. NIV was discontinued six hours later.

Reviewers considered that oxygen toxicity contributed to the ventilatory failure and that NIV could have been avoided with better management including controlled oxygen and nebulised bronchodilators.

Table 5.12 Patient was seen by respiratory staff

	Yes	%	No	%	Subtotal	Not answered	Total
Respiratory consultant	297	75.2	98	24.8	**395**	37	**432**
Respiratory ST3+	164	50.3	162	49.7	**326**	106	**432**
Respiratory specialist nurse	119	38.6	189	61.4	**308**	124	**432**
Respiratory physiotherapist	131	44.6	163	55.4	**294**	138	**432**

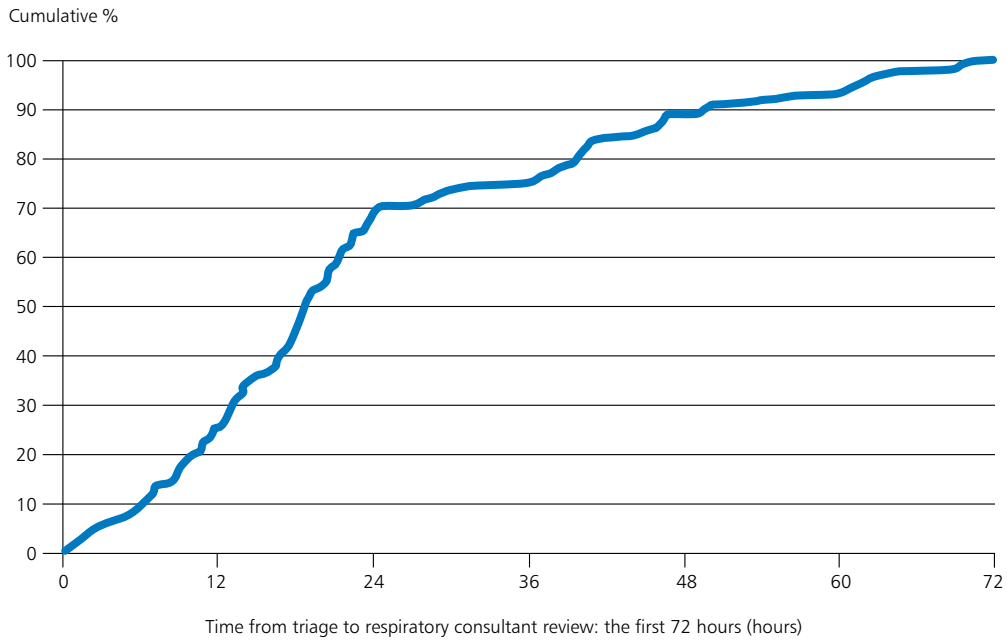

Figure 5.4 Time from triage to respiratory consultant review in the first 72 hours; n=133

Of the 219 cases where the timing of both NIV and consultant review were recorded, there were 171 where NIV was initiated prior to respiratory consultant review and 48 cases where the consultant review occurred prior to the initiation of NIV.

The value of specialist review is illustrated by the data presented in Table 5.13 and Table 5.14. In more than half of the patients (151/284; 53.2%), treatment changes were initiated as a result of this review. In the cases where treatment was changed, ventilator settings were altered in approximately a half (72/142; 50.7%) and non-ventilator treatments in almost three quarters (105/143; 73.4%) of cases.

Table 5.13 Specialist review resulted in treatment changes

	Number of patients	%
Yes	151	53.2
No	133	46.8
Subtotal	**284**	
Not answered	6	
Total	**290**	

Table 5.14 Changes made

	Change in ventilator settings		Change in non-ventilator treatments	
	Number of patients	%	Number of patients	%
Yes	72	50.7	105	73.4
No	70	49.3	38	26.6
Subtotal	**142**		**143**	
Not answered	9		8	
Total	**151**		**151**	

Medical decision to start NIV

As previously described, arrangements for NIV services vary considerably. There is concern that since NIV has become more available, responsibility for starting NIV treatment may have been delegated to junior staff without adequate support.

Table 5.15 shows that in 59/382 (15.5%) patients, the decision to start NIV was made by a junior member of medical staff. The speciality of the staff member who made this decision is also shown in Table 5.16.

Table 5.15 Grade of doctor who made decision to initiate NIV (number who were respiratory specialists)

	Number of patients	%
Consultant	108 (41)	28.3
Associate Specialist/Speciality doctor	39 (3)	10.2
Trainee with CCT	2 (0)	0.5
Senior specialist trainee	172 (35)	45.0
Junior specialist trainee	32 (2)	8.4
Basic grade	27 (3)	7.1
Specialist nurse / senior staff nurse	2 (1)	<1
Subtotal	**382**	
Unanswered	50	
Total	**432**	

Table 5.16 Doctor who made decision to initiate NIV

	Number of patients	%
General medicine	107	29.6
Respiratory medicine	85	23.5
Emergency medicine	61	16.9
Critical/intensive care medicine	43	11.9
Acute internal medicine	32	8.9
Cardiology	9	2.5
Geriatric medicine	8	2.2
Anaesthetics	5	1.4
Gastroenterology	5	1.4
Other	6	1.7
Subtotal	**361**	
Unanswered	71	
Total	**432**	

Medical review during NIV treatment

Management of NIV varies between hospitals. As noted in Chapter 2 (organisational data) models of care include doctors, nurses and/or physiotherapists leading ventilator management. This group of patients does however have a high risk of treatment failure and death.

Ongoing medical review to consider other treatment changes alongside ventilator management would be expected. For patients in acute medical and surgical units as well as high dependency and intensive care units, the expectation is for twice daily consultant review.[20]

Table 5.17 shows that in more than one in six of the peer reviewed cases, senior medical review did not take place on a daily basis.

Table 5.17 Daily senior medical review (ST3 or above) while on NIV recorded in the notes

	Number of patients	%
Yes	242	80.7
No	58	19.3
Subtotal	**300**	
Unknown	53	
Total	**353**	

With the increased availability of NIV, there is concern that junior staff who may not have the necessary knowledge or experience can be given responsibility for ventilator management. Reviewers were therefore asked if the grade of clinician involved in adjusting ventilator settings was appropriate. The grade was commonly not documented (135/353 cases). Where it was identifiable, in 31/218 (14.2%) cases the grade was felt not to be appropriate (Table 5.18).

Table 5.18 Appropriate grade of clinician involved in adjusting ventilator settings – reviewers' opinion

	Number of patients	%
Yes	187	85.8
No	31	14.2
Subtotal	**218**	
Not documented	135	
Total	**353**	

CASE STUDY 4

An elderly patient with COPD presented to hospital with breathing difficulty and drowsiness. Blood gas analysis confirmed severe respiratory acidosis. Acute NIV was commenced promptly at an inspiratory pressure of 12cm H_2O. NIV was delivered for three days with a maximum inspiratory pressure of 14cm H_2O. The patient was reviewed several times daily by junior medical staff. The patient remained tachypnoeic, drowsy and acidotic.

The reviewers thought that a higher inspiratory pressure should have been used and more senior review would have resulted in better NIV management.

5

Key Findings

- In nearly a fifth of cases treatment with NIV was not an appropriate intervention (66/351; 18.8%). In this group, 42 out of the 66 patients died
- In 80/352 (22.7%) cases, non-ventilator management prior to NIV was not appropriate and clinicians who reviewed the case notes in their own hospital found 72/422 (17.1%) cases where there was room for improved non-ventilator management. The areas for improvement that were identified included use of controlled oxygen therapy and better use of bronchodilators
- There were 58/348 (16.7%) cases where appropriate specialist review was not documented
- 297/395 (75.2%) patients were reviewed by a respiratory consultant during the admission
- In 151/284 (53.2%) patients treatment changes were initiated as a result of a senior review
- In the cases where treatment was changed, ventilator settings were altered in approximately a half (72/142; 50.7%) and in non-ventilator treatments in almost three quarters (105/143; 73.4%) of cases
- 59/382 (15.5%) of cases reviewed, the decision to start NIV was made by a junior member of medical staff.

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6

Non-invasive ventilation episode

Location of NIV delivery

Figure 6.1 shows the location in which NIV was commenced, continued and completed for 425 patients. The majority of NIV episodes (240/425; 56.5%) commenced in either the emergency department or an acute medical unit.

Of the 168 patients who started NIV in the emergency department, 21 patients completed their NIV there; 54 patients had NIV continued on a respiratory ward; 48 had their NIV continued on an acute medical unit and 41 were transferred to a critical care (ICU/HDU) setting. The location of where their treatment was continued will have been determined by a combination of disease severity and local arrangements for NIV delivery (see organisational chapter).

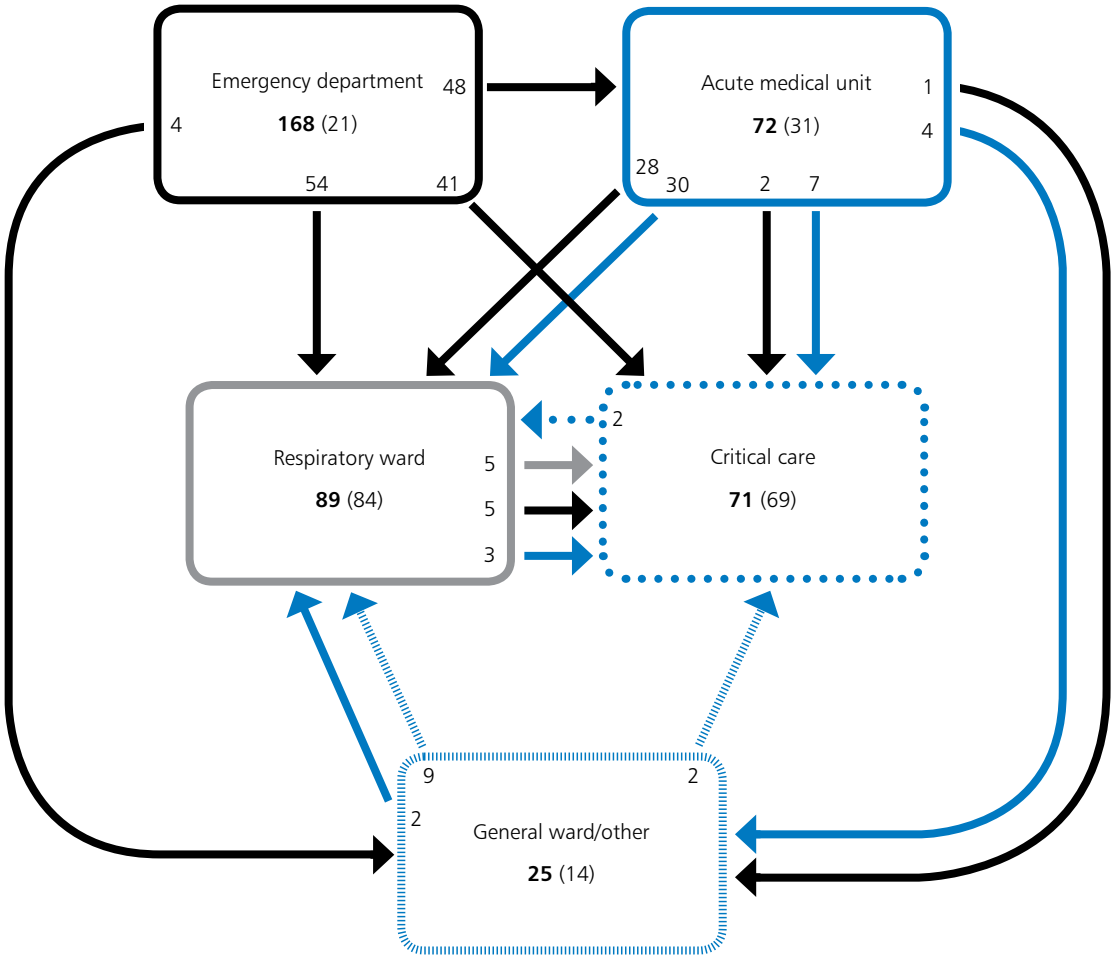

Figure 6.1 The flow of NIV patients through clinical areas in the hospital. Numbers in bold show where NIV was started, numbers in brackets where NIV was completed in the same location it was started, numbers by arrows where patients moved between locations whilst on NIV (arrows coded by the location NIV was started).

Of the 106 (48+54+4) patients who started NIV in the emergency department and continued it on an acute medical unit, respiratory ward or general ward, there were only 7 (5+2) patients who were subsequently transferred to critical care.

There were 84 patients who received all of their NIV on a respiratory ward. There were 120/(48+72) (28.2%) patients who received some treatment with NIV in an acute medical unit and 232/(89+54+28+30+2+9+2) (54.6%) patients where at least part of their NIV episode was provided on a respiratory unit.

Location of NIV delivery and severity of acidosis

Patients with a pH of less than 7.26 are at a much higher risk of treatment failure but they may still benefit from NIV.[21] It has therefore been recommended that patients with a pH lower than 7.26 are managed in an HDU or ICU setting.[6] In the 2013 British Thoracic Society acute NIV audit, 47% of COPD patients presented with a pH of less than 7.26 and 91% of these were managed in a ward based environment, not in critical care. When combined with the poor outcomes reported in this audit, this suggests a failure to appreciate the increased risk of NIV failure and death in these patients.

Figure 6.2 shows the pH at initiation of NIV and the area where this treatment was started. For 88/156 (56.4%) patients who started NIV in the emergency department, their pH was below 7.26. In this group of patients, there was a sub-group (28/88 patients) who were suffering from oxygen toxicity. This is discussed in Chapter 4. In cases of oxygen toxicity, rapid improvement in pH on combining NIV with lower oxygen saturation might be anticipated. Treatment with NIV in the emergency department rather than in critical care would be entirely appropriate in this group of patients.

There were 66/150 (44.0%) patients treated on acute medical units, respiratory or general wards with a starting pH <7.26. Of these 23 were referred to critical care and 10 of these patients were admitted to a critical care area for ongoing treatment. There were therefore more than a third of cases (56/150, 37.3%) where treatment was continued in a general ward area despite a high risk of treatment failure and guidelines that recommend a higher level of care.[6]

This raises concerns that it has become accepted practice to provide care of NIV patients in non-critical care areas despite a high chance of treatment failure. Where NIV represents the ceiling of treatment, this may be appropriate.

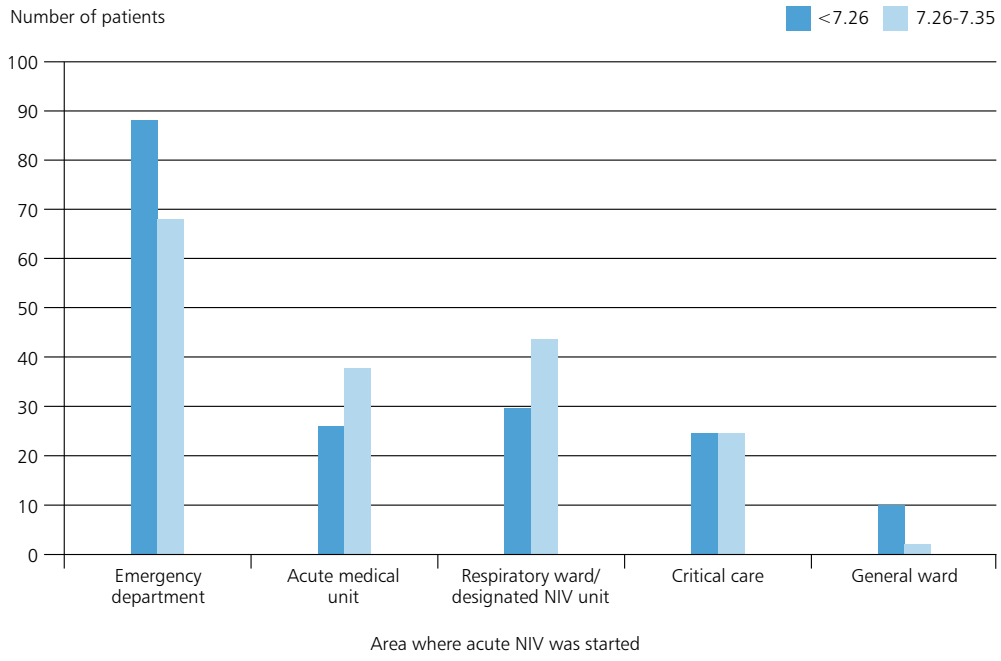

Figure 6.2 pH at initiation of NIV

Despite the apparently inappropriate location of delivery of NIV in these patients when compared with existing guidelines,[6] the reviewers only identified 19/284 (6.7%) cases, where they considered that NIV had not been delivered in an appropriate location (Table 6.1). They were unable to comment in an additional 69 cases.

Table 6.1 NIV delivered in appropriate location – reviewers' opinion

	Number of patients	%
Yes	265	93.3
No	19	6.7
Subtotal	**284**	
Unknown	69	
Total	**353**	

Treatment delay

The relationship between alveolar ventilation and carbon dioxide (CO_2) level is not linear. Once ventilation is inadequate and CO_2 levels have started to rise, small further decreases in ventilation can rapidly lead to worsening of CO_2 levels and acidosis. Severe respiratory acidosis can lead to drowsiness, loss of consciousness and eventually death. Timely initiation of ventilation is therefore of great importance. The NICE quality standard for COPD recommends that prompt receipt of NIV should be defined as receipt within one hour of the decision to administer NIV.[2] Prompt treatment requires staffing and equipment which are sufficient to cope with demand and a service design which gives rapid access to NIV treatment for all patients who need it.

The national NIV audit has shown that pH at initiation of NIV has worsened progressively with each audit cycle, most recently to a median value of 7.24.[3] One suggested reason for this is delayed initiation of NIV, allowing acidosis to deteriorate before NIV is started.

Table 6.2 shows that in the peer reviewed cases, the reviewers considered that there was a delay in starting NIV in 96/350 (27.4%) patients. Clinicians reviewing the case notes in their own hospital also identified delays in starting NIV in 63/420 (15.0%) patients.

Table 6.2 Delay in Starting NIV

	Reviewers' opinion		Clinicians' opinion	
	Number of patients	%	Number of patients	%
Yes	96	27.4	63	15.0
No	254	72.6	357	85.0
Subtotal	**350**		**420**	
Not answered	3		12	
Total	**353**		**432**	

Paired data from the clinicians and reviewers in Table 6.3 show that when the clinician identified delay, the reviewer was also able to do so in the majority (39/48) of cases. The reviewers however found an additional 41 cases that were not identified by the clinician where they considered there was delay. This illustrates the value of the peer review process.

Table 6.3 Delay in starting NIV – agreement between clinicians and reviewers

	Reviewers' opinion				
Clinicians' opinion	**Yes**	**No**	**Subtotal**	**Not answered**	**Total**
Yes	39	9	**48**	1	**49**
No	41	218	**259**	2	**261**
Subtotal	**80**	**227**	**307**	**3**	**310**
Not answered	4	6	**10**	0	**10**
Total	**84**	**233**	**317**	**3**	**320**

The reasons given for the delay in treatment are outlined in Tables 6.4 and 6.5. The most common reason given for this was a failure to recognise the need for NIV. The other common reason for delay was the need to transfer between clinical areas in order to start NIV. Data from the clinical questionnaire in Table 6.5 shows that in 118/422 (28%) of cases, local arrangements meant that the patient required transfer before starting treatment.

Table 6.4 Reason for the delay in NIV treatment

	Reviewers' opinion (n=96)	Clinicians' opinion (n=63)
Failure to recognise need	41	18
Required transfer	28	27
Lack of beds	11	0
Other	33	18

Answers may be multiple

Table 6.5 Ward transfer for treatment with NIV

	Number of patients	%
Yes - transferred before starting treatment	118	28.0
Yes - treatment initiated then transferred	113	26.8
No	191	45.3
Subtotal	**422**	
Not answered	10	
Total	**432**	

NIV equipment is light in weight and easily portable. A model where the NIV machine is taken to the patient and treatment is started before transfer to the area where it is continued can reduce delays. For the services that currently transfer patients to initiate NIV, this model should be considered.

CASE STUDY 5

An elderly patient was admitted with an exacerbation of COPD. A blood gas sample in the emergency department showed a pH of 7.28 and CO_2 of 8.7 kPa. The patient was referred for admission and reviewed by the medical registrar three hours later. The need for NIV was identified but the patient waited a further four hours for a bed on the respiratory ward. NIV was eventually started 8 hours after the blood gas revealed acute hypercapnic respiratory failure. The patient improved with NIV treatment and was discharged five days later.

The reviewers thought that delay was caused by both the clinical assessment and the local arrangements for NIV provision. Either NIV should have been started in the emergency department, or rapid transfer to the NIV unit should have been facilitated.

While the data above relate to delay in starting NIV treatment, the use of NIV might in some cases introduce delay in the pathway if intubation and invasive ventilation is more appropriate. Just over one in ten of the cases reviewed (37/345; 10.7%) had a severe acidosis documented where the reviewers considered that invasive ventilation would have been a more appropriate intervention (Table 6.6).

Table 6.6 Severity of the initial acidosis suggests immediate intubation would have been more appropriate – reviewers' opinion

	Number of patients	%
Yes	37	10.7
No	308	89.3
Subtotal	**345**	
Not answered	8	
Total	**353**	

Monitoring and documentation

The national guideline in place at the time of this study recommended monitoring including oximetry and ECG during the first 12 hours of NIV treatment, and physiological monitoring including regular blood pressure, respiratory rate and conscious level assessment.[6] This guideline also recommended assessment of the clinical response to treatment with blood gas analysis at 1, 4 and 12 hours after initiation of treatment. The guideline did not specifically make recommendations about documentation of ventilator settings but provided a template which could be used to make these recordings. (Appendix 1).

Organisational aspects of monitoring are discussed in Chapter 2. In the cases assessed, reviewers found that in more than half (180/350; 51.4%) of the cases ventilator settings were not adequately documented (Table 6.7).

Table 6.7 Ventilator settings adequately documented – reviewers' opinion

	Number of patients	%
Yes	170	48.6
No	180	51.4
Subtotal	**350**	
Not answered	3	
Total	**353**	

Vital signs monitoring

The 2016 acute hypercapnic respiratory failure guidelines were published after cases were identified for inclusion in this study.[7] These did not make specific recommendations about the frequency of vital signs monitoring during NIV. However, use of the National Early Warning Score (NEWS) is recommended. Details of NEWS have been described previously in Chapter 4. The NEWS on admission suggests that at least hourly monitoring would be appropriate in the majority of patients and that this could be identified at the time of initial assessment.

Although a measure of NEWS was not collected at the start of the NIV episode, data on all NEWS variables except temperature were collected to assess monitoring of NIV. Table 6.8 shows the individual NEWS parameters for each variable at the start of NIV. This shows that over half of the patients had a respiratory rate of 25 or more. In addition to high respiratory rates, at the start of NIV over half (136/259; 52.5%) of the patients scored for low oxygen saturation. Almost all (418/432; 96.8%) of the patients were being treated with oxygen which adds two points to the score.

Table 6.8 NEWS categories at start of NIV

NEWS parameter (n)	NEWS 0 (%)	NEWS 1 (%)	NEWS 2 (%)	NEWS 3 (%)
Respiratory rate (254)	72 (28.3) *RR of 12-20*	1 (<1) *RR of 9-11*	54 (21.3) *RR of 21-24*	128 (50.4) *RR of ≤8 or ≥25*
Heart Rate (245)	87 (35.5) *HR of 51-90*	84 (34.3) *HR of 41-50 or 91-110*	58 (23.7) *HR of 111-130*	16 (6.5) *HR of ≤40 or ≥131*
Blood pressure (240)	186 (77.5) *BP of 111-219*	23 (9.6) *BP of 101-110*	18 (7.5) *BP of 91-100*	13 (5.4) *BP of ≤90 or ≥220*
Conscious level* (226)	168 (74.3) *A*			58 (25.7) *V,P or U*
Oxygen saturation (259)	51 (19.7) *O2 of ≥96*	32 (12.4) *O2 of 94-95*	40 (15.4) *O2 of 92-93*	136 (52.5) *O_2 of ≤91*
Oxygen use (432) Clinician Q. data	14 (3.2) *No*		418 (96.8) *Yes*	

**For cases where GCS given for conscious level, GCS 14 or 15 counted as alert on AVPU*

These data on vital signs and NEWS show that the group of patients who were treated with NIV had severely abnormal physiology. Monitoring at least hourly and consideration of an enhanced care environment is appropriate for such a sick group of patients. Despite the severity of illness, the reviewers found that the frequency of documentation of vital signs was not appropriate in over a third (104/311; 33.4%) of patients (Table 6.9).

Table 6.9 Appropriate frequency of documented observations during NIV – reviewers' opinion

	Number of patients	%
Yes	207	66.6
No	104	33.4
Subtotal	**311**	
Unknown	42	
Total	**353**	

Blood gas sampling

In addition to monitoring clinical parameters, blood gas sampling is used to assess response to ventilation. Improvement of CO_2 and resolution of acidosis reflect improved alveolar ventilation. As noted above, blood gas analysis at one and four hours after initiation of ventilation is recommended.

CASE STUDY 6

A patient with and exacerbation of COPD, was admitted to the acute respiratory unit with a respiratory rate of 28 and a CO_2 9.4 kPa, pH 7.25. They were started promptly on NIV and slowly improved. Ventilation was continued for four days and the patient was discharged home after a week.

The reviewers commented that the records contained a well-designed NIV observation chart. Despite the good outcome, it was difficult to comment on the quality of NIV treatment as the chart for monitoring vital signs and ventilator settings was poorly completed.

The majority of peer reviewed cases (172/290; 59.3%) had between one and five blood gas samples while receiving NIV (Figure 6.3). For patients managed in a critical care area with invasive arterial monitoring, samples were taken with a similar frequency to those patients without invasive access for blood sampling (data not shown).

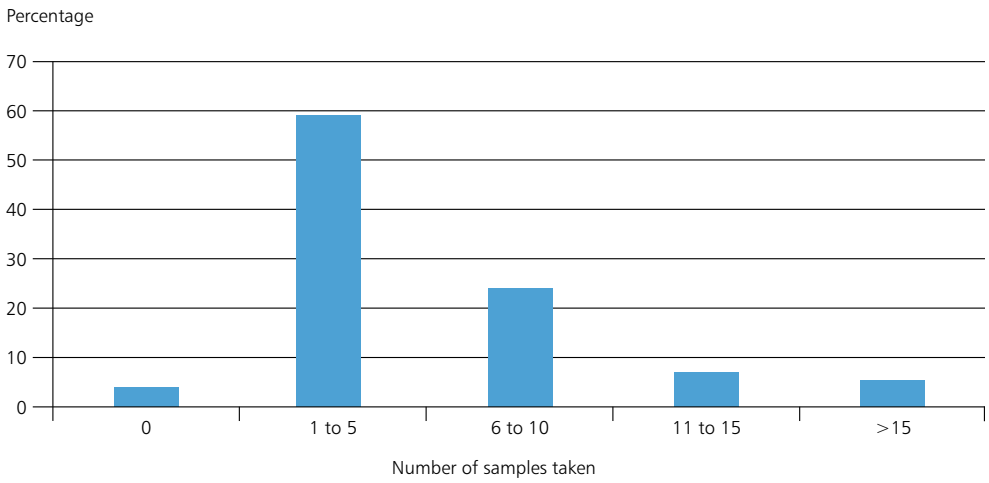

Figure 6.3 Number of blood gas samples; n=290

The reviewers found that blood gas sampling was too infrequent in almost a third of cases (107/331; 32.3%) (Table 6.10). They also identified room for improvement in patient monitoring in 121/265 (45.7%) cases (Table 6.11).

Table 6.10 Frequency of blood gas sampling – reviewers' opinion

	Number of patients	%
Appropriate	195	58.9
Too infrequent	107	32.3
Too frequent	29	8.8
Subtotal	**331**	
Not answered	22	
Total	**353**	

Table 6.11 Patient monitoring could have been improved – reviewers' opinion

	Number of patients	%
Yes	121	45.7
No	144	54.3
Subtotal	**265**	
Unknown	88	
Total	**353**	

Oxygen administration during non-invasive ventilation

For patients treated with NIV, a target oxygen saturation of 88-92% is recommended.[6,7] A target saturation was not prescribed in between 22.1% (91/412; clinician data) and 30.1% (105/349; reviewer data) of cases (Table 6.12).

In general, when a target was prescribed, in both the cases reviewed and from the information provided by the patient's own clinician the recommended 88-92% value was chosen.

Table 6.12 Target saturation prescribed

	Reviewers' opinion		Clinicians' opinion	
	Number of patients	%	Number of patients	%
88-92%	207	59.3	296	71.8
94-98%	16	4.6	17	4.1
Other	21	6.0	8	1.9
Not prescribed	105	30.1	91	22.1
Subtotal	**349**		**412**	
Not answered	4		20	
Total	**353**		**432**	

When asked whether the target saturation was achieved, there was less agreement between reviewers and the clinician responsible for the patient. Reviewers found that the target saturation was achieved in 59.2% (135/228) of cases. It was far more common for the saturation achieved to be higher rather than lower than prescribed from both sources of data (Table 6.13). Higher oxygen saturation levels could have an adverse effect on spontaneous ventilation at times when NIV is discontinued. A target saturation was therefore either not prescribed nor achieved in at least 198/353 (56.1%) of the cases reviewed.

Table 6.13 Target saturation achieved

	Reviewers' opinion		Clinicians' opinion	
	Number of patients	%	Number of patients	%
Yes	135	59.2	252	82.1
No - too high	77	33.8	40	13.0
No - too low	16	7.0	15	4.9
Subtotal	**228**		**307**	
Not answered	16		13	
Total	**244**		**320**	

The method of oxygen administration while on ventilation is important when using NIV. Most ventilators used to deliver this treatment are simple machines that pump filtered air under pressure. Oxygen is added to the system either through the ventilator tubing or through a port in the patient's mask. If there is a leak around the mask, higher flow rates are delivered by the ventilator to maintain the target pressure in the system. The constant flow of oxygen is diluted by the increased flow through the ventilator circuit, lowering the overall concentration of oxygen delivered to the patient. In this circumstance, oxygen delivery is therefore not controlled. In addition, high concentrations of oxygen cannot be delivered as most of the gas flow through the system is air.

Table 6.14 shows that in 258/370 (69.7%) cases, oxygen was entrained through the tubing or mask. In 98/370 (26.5%) oxygen was pre-mixed through the ventilator. Pre-mixing would allow higher concentrations of oxygen to be delivered. It was encouraging to note that the frequency of inadequate oxygenation in this context was low (between 5 and 7%; Table 6.13).

Table 6.14 Method of oxygen administration

	Number of patients	%
Entrained through mask/tubing	258	69.7
Pre-mixed through ventilator	98	26.5
Oxygen not administered	14	3.8
Subtotal	**370**	
Not answered	62	
Total	**432**	

Ventilator management

The guidelines in place at the time of this study recommended setting up the ventilator with an initial expiratory pressure of 4-5 cm H_2O.[6] Applying expiratory pressure helps to vent CO_2 from the ventilator circuit which prevents re-breathing. It also helps ventilator triggering. Changes to expiratory pressure settings are not recommended without specialist input.

A low starting inspiratory pressure of 10 cm H_2O is suggested to ensure the patient is able to tolerate the applied pressure. Improved ventilation (and therefore removal of CO_2) depends on the level of inspiratory pressure applied. The need to apply a level of pressure that is enough to reduce CO_2 levels therefore needs to be balanced against patient comfort. After NIV has been started, an incremental increase in inspiratory pressure in 2-5 cm H_2O steps is recommended, with a target of increasing the pressure by 5 cm H_2O every 10 minutes. A target pressure of 20 cm H_2O is recommended as the level at which adequate support is likely to be delivered.

The 2016 acute hypercapnic respiratory failure guideline has provided more detailed advice on ventilator support in conditions other than COPD.[7] The most important difference compared with the 2008 document[6] is a higher starting inspiratory pressure with more rapid up-titration. Specifically, a starting pressure of 15 cm H_2O is recommended (20 cm H_2O if initial pH is less than 7.25), increasing to 20-30 cm H_2O within 10-30 minutes.

Assessment of the effectiveness of ventilation involves both clinical assessment and blood gas analysis. A fall in the respiratory rate and improvement in chest wall movement are the most important aspects of clinical assessment that reflect success of ventilation.

Time on ventilation

In some patients, in particular when escalation is not appropriate, NIV is given as a trial of treatment with a lower chance of success. In these patients the length of the NIV episode might be expected to be shorter than when it is successful. For the 164 patients with documented start and end times for their ventilation episode, the time on NIV for 105 survivors was longer than for the 59 patients who died (Figure 6.4).

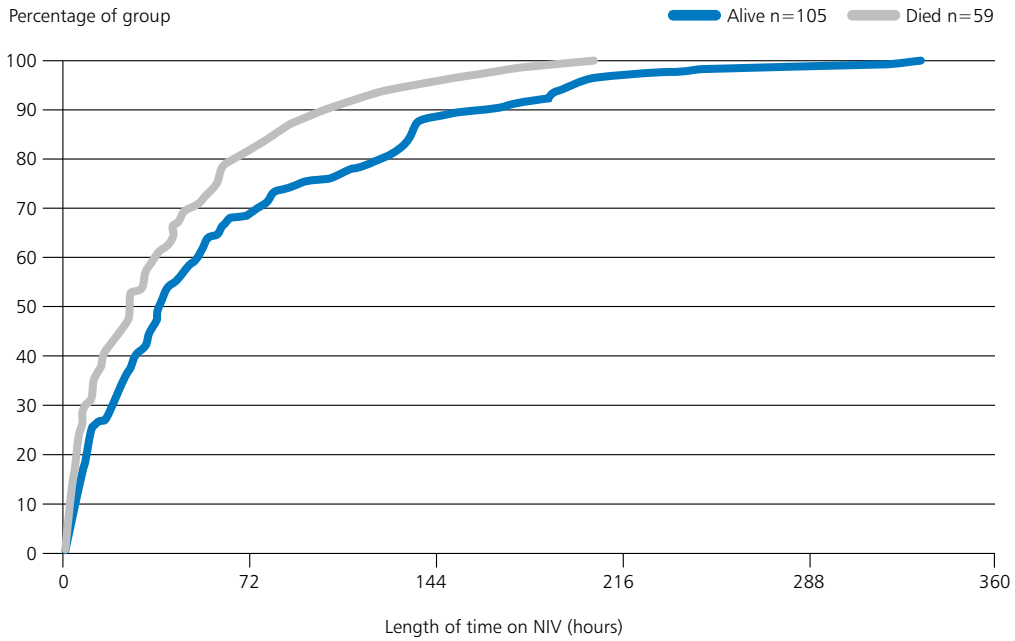

Figure 6.4 Length of time on NIV by outcome; n =164 with documented start and stop times: 105 survivors (blue), 59 deaths (grey) shown as % of each group

Table 6.15 NIV completion within 24, 48 and 72 hours

Number (%) completed NIV episode	24 hours	48 hours	72 hours
Alive (105 patients)	37 (35.2)	60 (57.1)	72 (68.6)
Died (59 patients)	27 (45.8)	41 (69.5)	48 (81.4)

In the survivors, 35.2% (37/105) of patients had completed the ventilation episode in 24 hours, and in those patients who died, this value was 45.8% (27/59). The percentage completing NIV within 48 and 72 hours is also shown in Table 6.15

Initial treatment / set up

Initial pressure settings used for patients included in this study are shown in Figure 6.5 overleaf. In most patients, expiratory pressure followed the BTS guidelines,[6] with 245/314 (78.0%) patients having a starting pressure of 4 or 5 cm H_2O.

Similarly, in 213/312 (68.3%) patients, initial inspiratory pressure was set between 10 and 15 cm H_2O (Figure 6.6).

However, in 59/295 (20.0%) patients the reviewers thought the initial ventilator settings were not appropriate (Table 6.16).

Table 6.16 Appropriate initial ventilator settings – reviewers' opinion

	Number of patients	%
Yes	236	80.0
No	59	20.0
Subtotal	**295**	
Not answered	58	
Total	**353**	

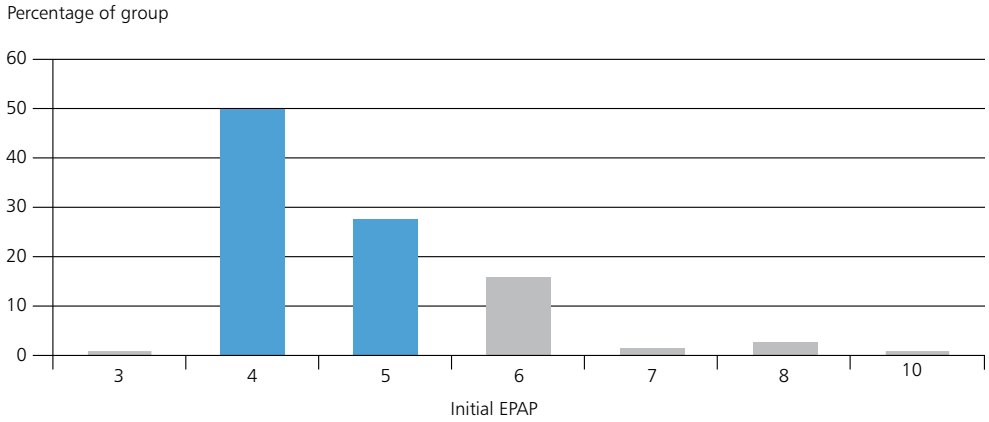

Figure 6.5 Initial expiratory positive airway pressure (EPAP); n=314 (guideline recommended pressure in blue)

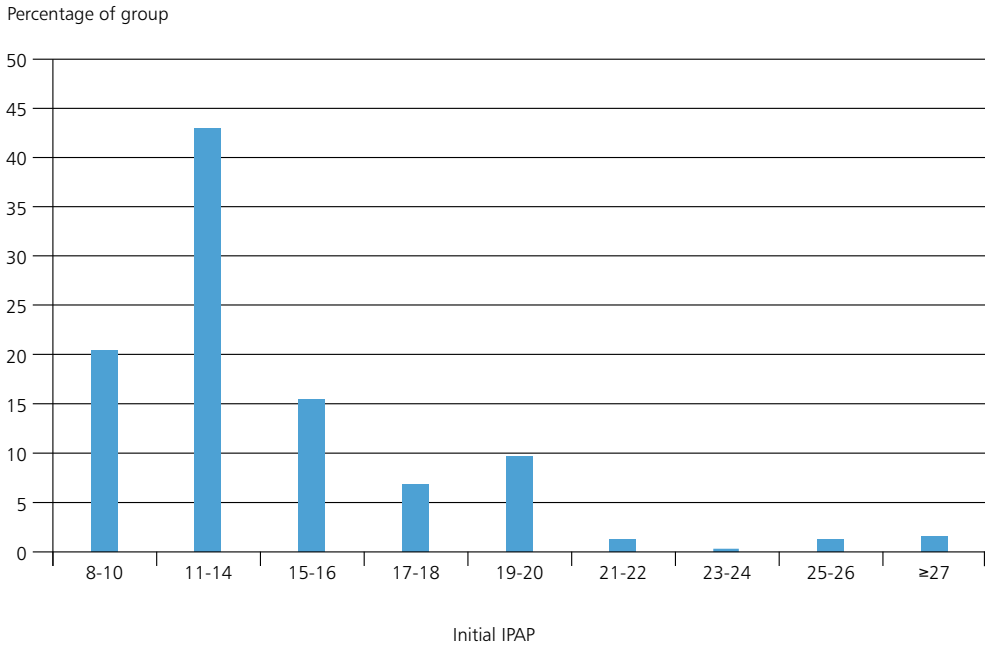

Figure 6.6 Initial inspiratory positive airway pressure (IPAP); n=312

Pressure titration

As stated earlier, BTS guidelines recommend that the expiratory pressure is not increased. Expert review is recommended in patients treated with an expiratory pressure of more than 8 cm H_2O.[7]

Higher expiratory pressure can be useful in patients with upper airway obstruction due to obstructive sleep apnoea or obesity hypoventilation, in some cases of patient ventilator asynchrony and to improve oxygenation in hypoxic patients. In all of these circumstances, specialist respiratory or critical care assessment would be expected. During the NIV episode

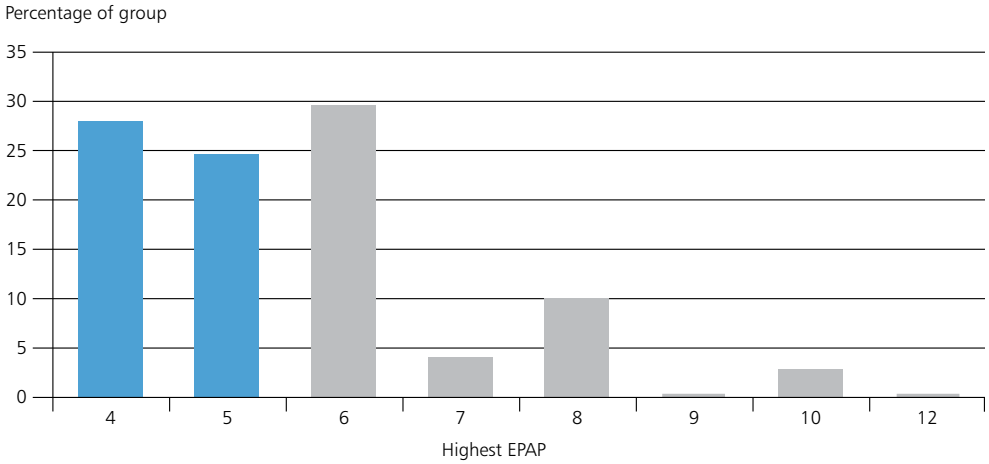

Figure 6.7 Highest expiratory positive airway pressure (EPAP); n=241 (guideline recommended initial pressure in blue)

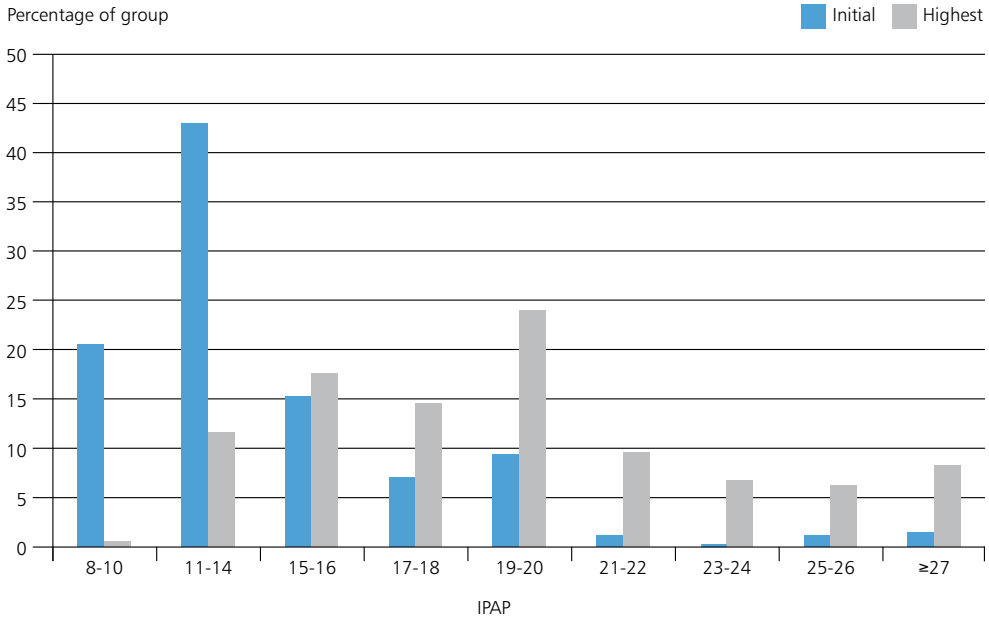

Figure 6.8 Highest delivered inspiratory positive airway pressures (IPAP); n=266 (% at initial values shown for comparison)

there was a tendency for the expiratory pressure to be higher at the end of the episode than at onset. At the end of NIV treatment, there were 43/241 (17.8%) patients with an expiratory pressure setting above 6 cm H_2O compared with 16/314 (5.1%) on the initial settings (Figure 6.7). Inspiratory pressure titration is a key aspect of successful NIV. The difference between inspiratory and expiratory pressure determines the increase in ventilation delivered. Figure 6.8 shows the highest pressure used for 266 patients where this was recorded with the percentage at each starting pressure presented for comparison.

Table 6.17 Appropriate subsequent ventilator management – reviewers' opinion

	All Reviewed cases		No pressure increase		IPAP <20 cm H_2O	
	Number of patients	%	Number of patients	%	Number of patients	%
Yes	188	65.3	30	66.6	64	58.2
No	100	34.7	15	33.3	46	41.8
Subtotal	**288**		**45**		**110**	
Not answered	65		7		10	
Total	**353**		**52**		**120**	

The highest inspiratory pressure was not documented in 87/353 (24.6%) cases. In the 266 cases where this was documented, there were 120 (45.1%) cases where the maximum pressure delivered did not reach 20 cm H_2O. In 52/252 (20.6%) patients overall the highest inspiratory pressure delivered was no higher than the initial setting.

Reviewers frequently commented that pressure was not increased adequately to treat the patient's condition. When inspiratory pressure settings were compared between cases not managed appropriately, and the rest of the patients included in this study, there was no difference in the pressure applied between the groups (data not shown).

Due to the reviewers' comments about pressure titration, the 52 patients who did not have their ventilator pressure increased above the initial pressure setting and the 120 who never achieved an inspiratory pressure of 20 cm H_2O were examined in more detail. Poor outcome (NIV failure and mortality) was not increased in these groups. There was also no clear difference in how the reviewers rated the appropriateness of ventilator management in these cases compared with the whole study population. Reviewers rated the ongoing ventilator management after initial set up as not being appropriate in 100/288 (34.7%) cases (Table 6.17).

The data in this section show that although adequate pressure titration is important in delivering NIV, and guidelines encourage up-titration of the ventilator pressure, the actual pressure required varied between patients. The adequacy of ventilation did not depend simply on the pressure delivered, but was part of a composite assessment that included other clinical parameters that reflected success or failure of NIV.

Clinical response to ventilation

The primary goal of ventilation is to reduce CO_2 levels. As CO_2 in the blood is a weak acid, falling CO_2 levels cause an improvement (rise) in pH. The availability of equipment to monitor vital signs and access to blood gas analysis to assess patients on ventilation was discussed in Chapter 2 (organisational data). The importance of vital signs monitoring from the start of the NIV episode was also discussed in Chapter 4.

Meta-analyses of NIV in COPD patients, have shown that improvement in pH and $PaCO_2$ as well as reduction in respiratory rate after one hour of NIV are the best indicators of successful treatment.[22,23] Guidelines have recommended measurement of blood gases to monitor pH and CO_2 levels as a minimum at one and four hours after starting NIV.[6]

Worsening CO_2 levels and acidosis can cause a reduced conscious level. Assessment of conscious level is included with other physiological variables in recommendations for monitoring of all hospital patients.[14] When deterioration in clinical parameters occurs, it represents an opportunity to review all aspects of the patient's treatment and the involvement of a senior decision maker is appropriate. This may result in changes to medical treatment, and adjustment of ventilator settings to improve patient synchronisation with the ventilator and/or to improve elimination of CO_2.

It may also result in a different approach to treatment including intubation where indicated or withdrawal of treatment in some cases.

There were signs of deterioration on NIV in 145/345 (42.0%) patients (Table 6.18).The specific signs that were present are listed in Table 6.19. The most common feature was worsening acidosis which occurred in 70 of the patients. The other features (rising respiratory rate, falling conscious level and agitation/intolerance) would all be identified by close clinical observation or vital signs monitoring.

Table 6.18 Signs of deterioration during NIV – reviewers' opinion

	Number of patients	%
Yes	145	42.0
No	200	58.0
Subtotal	**345**	
Not answered	8	
Total	**353**	

Table 6.19 Specific signs of deterioration

	Number of patients
Rising respiratory rate	39
Worsening acidosis	70
Falling conscious level	39
Agitation/intolerance	53

Answers may be multiple; n=142 (3 not answered)

In the majority of cases (100/145; 69.0%) clinical deterioration did result in clinical review of the patient (Table 6.20). In 45 patients, ventilator settings were changed and in 31 cases, ventilation was discontinued. In 13 cases, the patient was intubated and in seven, sedation was introduced to improve patient toleration of NIV. The reviewers felt that in 33/138 (24.0%) cases the action taken was not appropriate (Table 6.21).

Table 6.20 Action taken when clinical deterioration identified

	Number of patients
Clinical review	100
Change in mask	4
Change of ventilator settings	45
Intubation	13
Ventilation stopped	31
Sedation	7
No action taken	11
Not answered	2

Answers may be multiple; n=145

Table 6.21 Appropriate action taken to clinical deterioration – reviewers' opinion

	Number of patients	%
Yes	105	76.1
No	33	23.9
Subtotal	**138**	
Not answered	7	
Total	**145**	

CASE STUDY 7

A patient with obesity hypoventilation syndrome was admitted acutely and started on NIV on the acute medical unit. Inspiratory pressure was increased to 26 cm H_2O over the first two hours of treatment but after eight hours, the patient deteriorated with worsening acidosis and falling conscious level. The medical registrar reviewed the patient and increased the inspiratory pressure to 28 cm H_2O. The patient was subsequently admitted to the high dependency unit for ongoing treatment.

The reviewers considered that the patient required a more complex approach to ventilation including a higher expiratory pressure. Senior decision making and early respiratory specialist review would have improved management.

pH and CO_2 response to ventilation

In line with good practice, pH values at the onset of ventilation and at one and four hours were recorded for 234 patients. Of these, 133 patients survived and 101 died. It is of note that the average pH at initiation of ventilation was below 7.25, the lower end of the range where NIV has the best evidence of success. Even after four hours of ventilation the mean value of pH was still below the normal range of 7.35-7.45 in both groups (Table 6.22 and Figure 6.9)

There did not appear to be a difference in the pH response to ventilation between the patients who survived and those who died during the first four hours of treatment.

The difference in pH response to ventilation was clearer at the end of the ventilation episode. This is shown for 194 patients in Figure 6.10. In survivors, the average pH at initiation of NIV was 7.247, rising to an average of 7.402 which reflected success of ventilation in correcting the acidosis. In patients who died, the average starting pH was 7.261. In this group, the pH failed to correct and the final pH on stopping NIV remained below normal at 7.317.

Table 6.22 Mean values of pH during NIV episode

	Initiation	1 hour	4 hours
Alive (133 patients)	7.231	7.279	7.321
Died (101 patients)	7.233	7.282	7.311

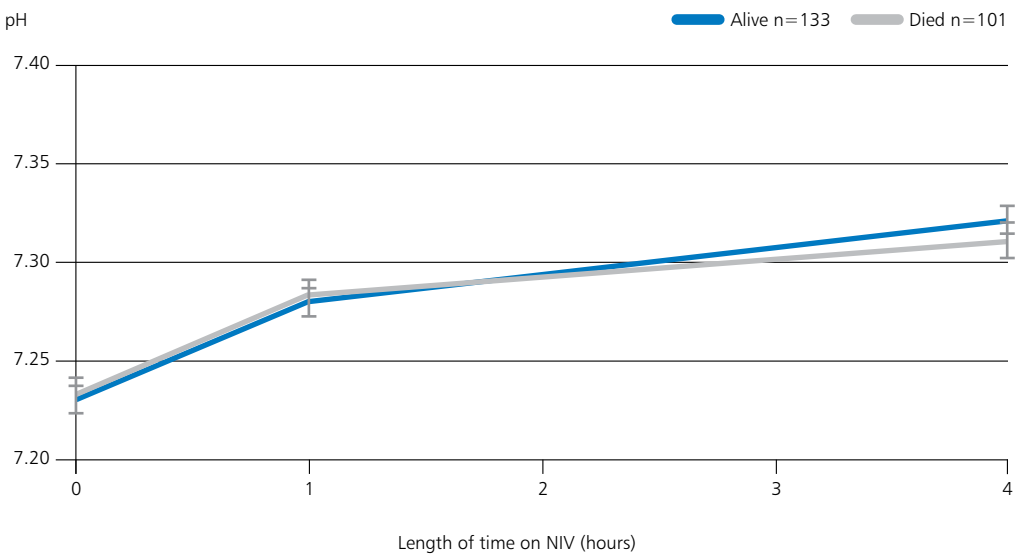

Figure 6.9 pH level at 0, 1 and 4 hours on ventilation (mean and standard error) for patients who survived and those who died (where values recorded at the three time points were available)

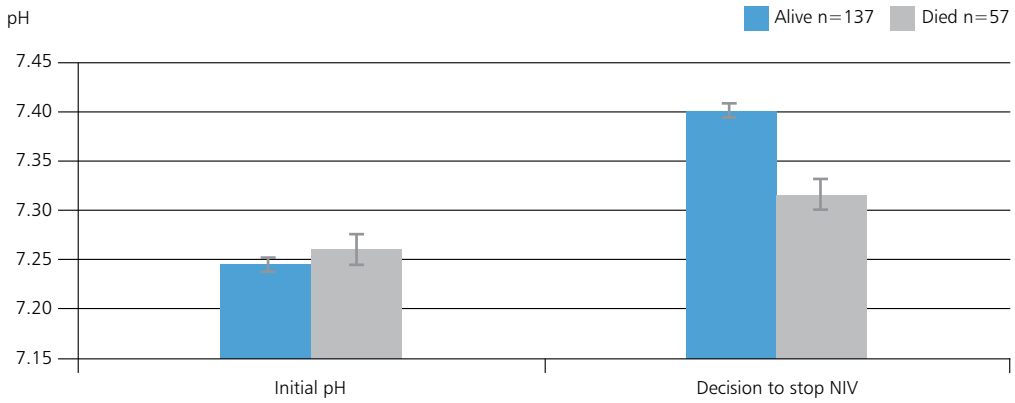

Figure 6.10 pH response to ventilation at initiation and at the end of the ventilation episode

The average time to correct the acidosis was just under 22 hours for 148 patients where pH values were available for both time points (Table 6.23).

Table 6.23 Time in hours to correct the acidosis

	Time in hours to normalise pH	Length of time in hours, on NIV
Mean	21:39	79:24
Median	12:17	55:02

When these cases were divided according to the severity of the acidosis, in those patients with a lower initial pH, this took longer to correct (Table 6.24).

Table 6.24 Time to correct acidosis by pH level

	<7.26	≥7.26
Mean	26:54	17:39
Median	18:40	10:52
n=	**63**	**83**

As already noted, the primary purpose of ventilation is to improve elimination of CO_2. Figure 6.11 shows the average CO_2 levels at the start of NIV and at one and four hours, in survivors and patients who died. Similarly, Figure 6.12 shows the average CO_2 values at the start and end of NIV treatment. Figures 6.11 and 6.12 are shown overleaf.

These results illustrate the effectiveness of ventilation which brings CO_2 levels down in the first hour of treatment. In patients who died, CO_2 levels fell less over the whole NIV episode, than in patients who survived despite the average starting CO_2 level being higher in survivors. It is worth noting that even at the end of the NIV episode, the mean CO_2 level in survivors was 7.22 kPa (Figure 6.12). A recent study has shown that in COPD patients with a persistently raised CO_2 level (above 7 kPa), treatment with long term overnight ventilation improved admission free survival by over 50%.[24]

Other physiological parameters

Respiratory rate has been shown to be the most important vital sign used to assess treatment success in NIV with improvement at one hour being predictive of treatment success. The respiratory rate at initiation, one and four hours was recorded in 190 patients (Table 6.25). Of these, 133 patients survived and 57 patients died (Figure 6.13).

Table 6.25 Mean values of respiratory rate during NIV episode

	Initiation	1 hour	4 hours
Alive (133 patients)	25	24	22
Died (57 patients)	28	27	26

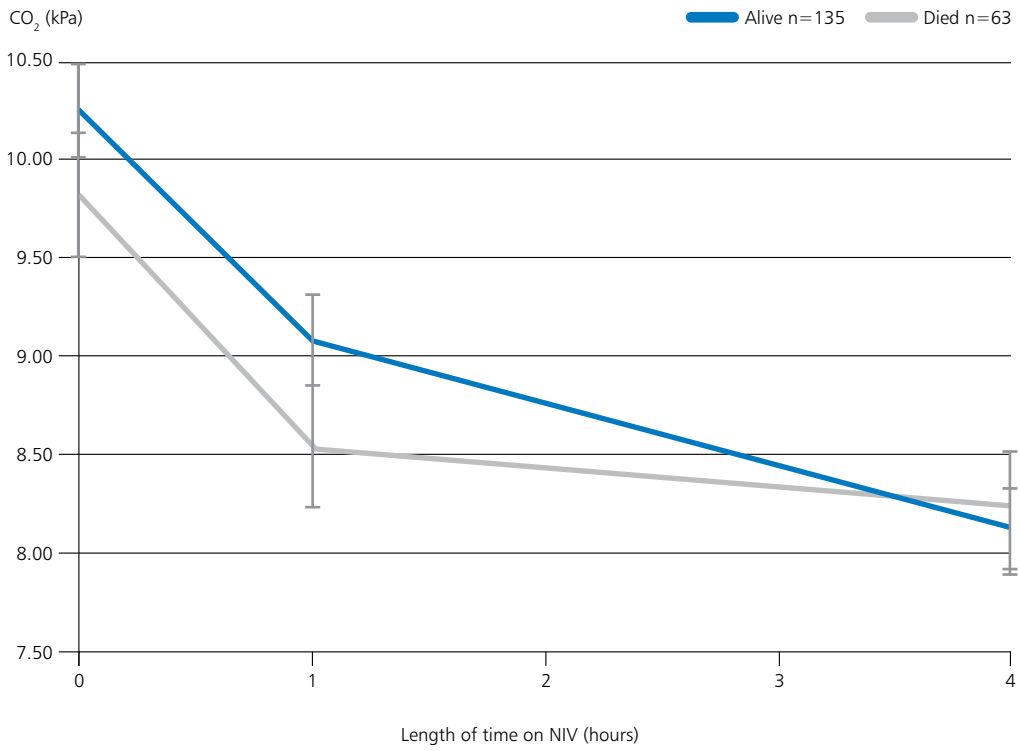

Figure 6.11 Change in CO_2 on NIV (mean and standard error) for patients who survived and those who died (where values recorded at the three time points were available)

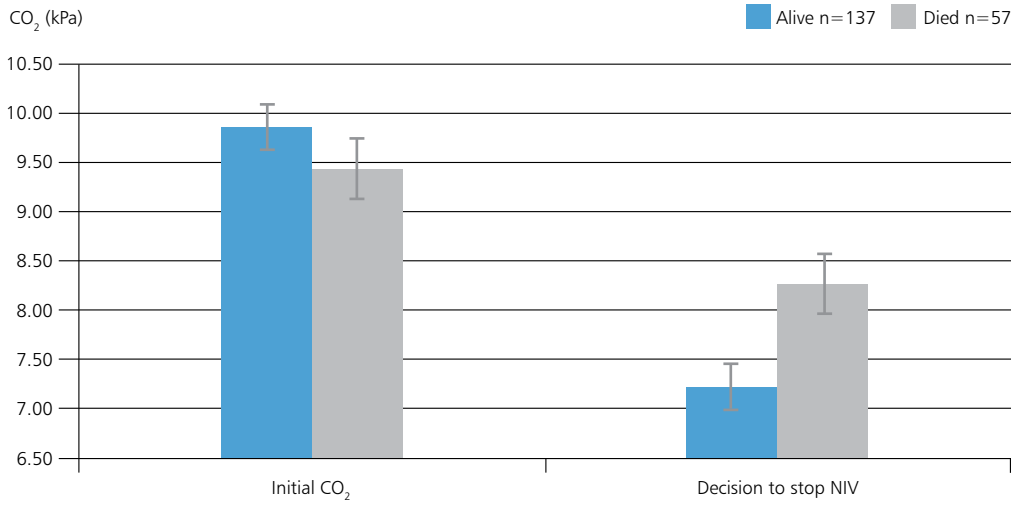

Figure 6.12 CO_2 level at start and end of ventilation (mean and standard error)

It can be seen that when taken as a group, the average respiratory rate was higher in patients who died at all of the time points (Table 6.25 and Figure 6.13). On average, when patients died, although the respiratory rate fell in the first one and four hours, as a group the rate at four hours was still higher in deaths than it was in survivors at initiation of NIV.

Data for respiratory rate at the start and end of NIV showed similar results in the 157 patients where it was recorded (Figure 6.14). In survivors, the average respiratory rate improved on treatment from 25 to 21 (114 patients). In patients who died, the average respiratory rate was 29 at the beginning of the NIV episode and 26 when NIV was discontinued (43 patients).

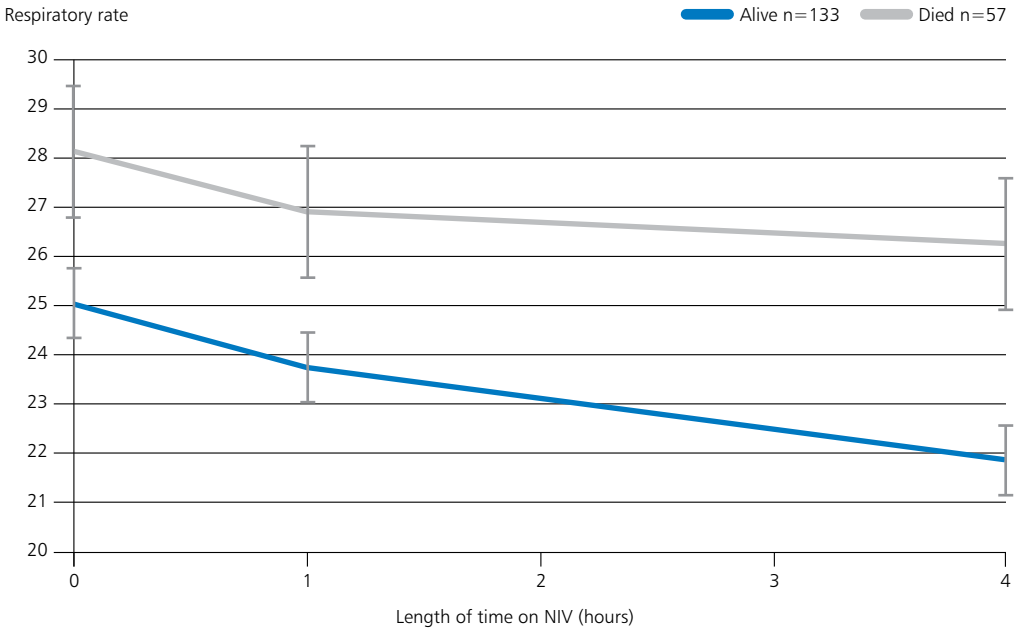

Figure 6.13 Change in respiratory rate on NIV (mean and standard error) for patients who survived and those who died (where values recorded at the three time points were available)

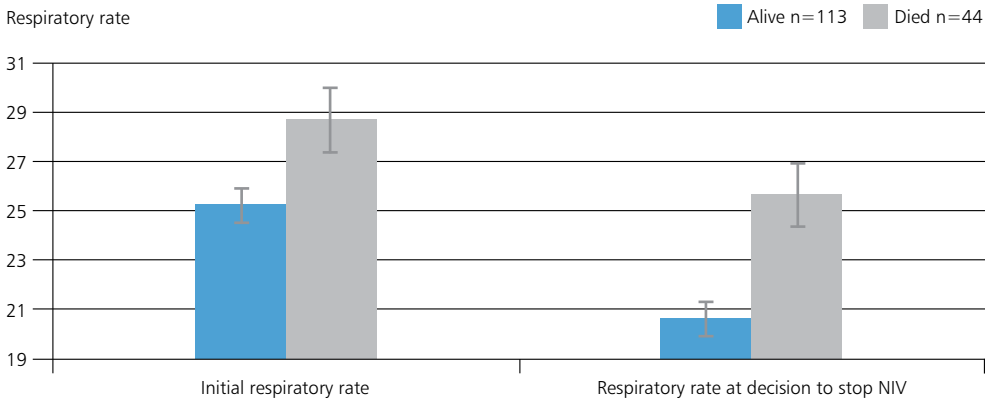

Figure 6.14 Respiratory rate at start and end of ventilation (mean and standard error)

Vital signs other than respiratory rate are not specified as part of the assessment of the response to NIV. However they are part of the National Early Warning Score (NEWS) which has been promoted for use in assessment of hospital patients and was discussed earlier.[14]

Similarly to respiratory rate data, for 184 patients where the values were available average heart rate values were higher at all of the time points in patients who died than in those who survived (Figure 6.15). This also applied to the 155 patients where the heart rate was recorded at the start and the end of NIV treatment (Figure 6.16).

Of these patients, 28/184 (15.2%) had an initial heart rate of more than 120 per minute at the start of the NIV episode. Current guidelines recommend continuous ECG monitoring for this group.[6]

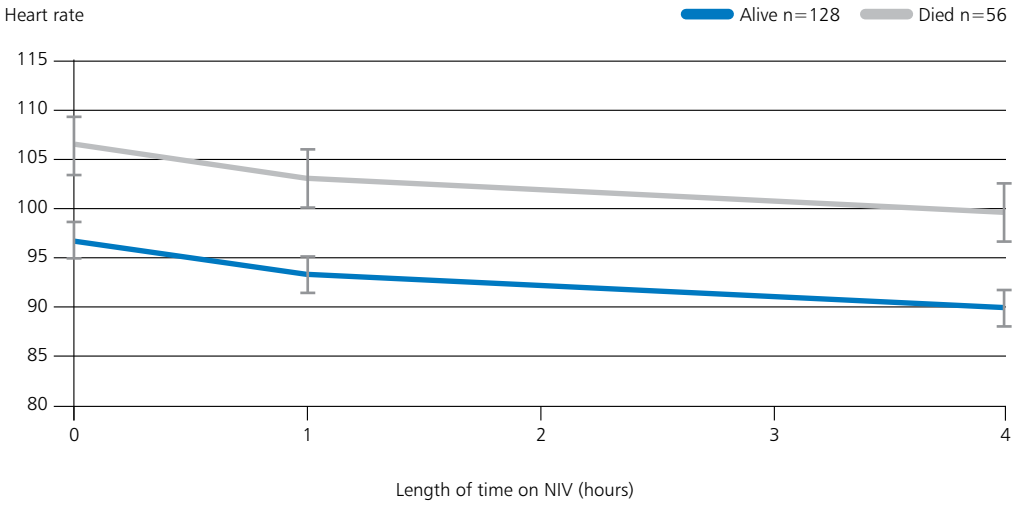

Figure 6.15 Change in heart rate on NIV (mean and standard error) for patients who survived and those who died (where values recorded at the three time points were available)

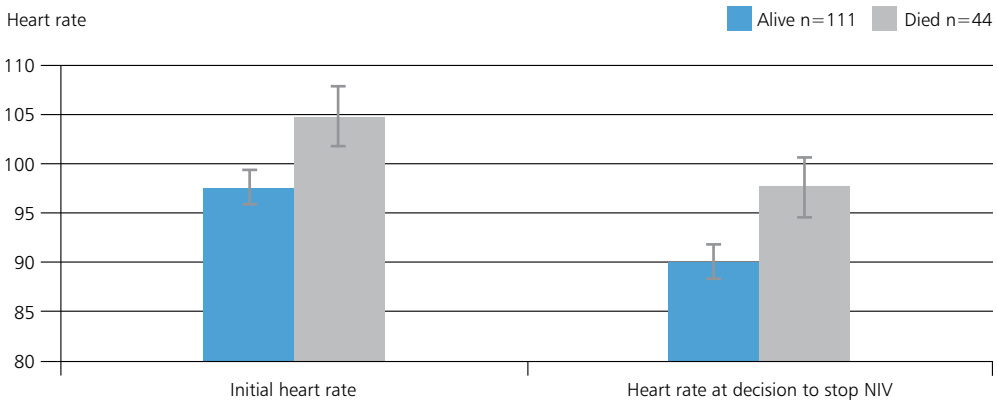

Figure 6.16 Heart rate at start and end of ventilation (mean and standard error)

Level of consciousness

Rising CO_2 levels can lead to reduced level of consciousness. A reduced conscious level is also associated with a worse clinical outcome. Where conscious level was recorded at the start of the NIV episode, 28/67 patients who died had a reduction in GCS (to 13 or below) or were not alert on AVPU score. For patients who survived, 30/159 (18.9%) started with reduced consciousness at this level.

End of NIV treatment

In 90/322 (28%) patients, the reviewers felt that ventilation was not discontinued at an appropriate time (Table 6.26). In 29 of these it was continued for too long, either due to a failure to recognise that the patient was dying or a failure to wean from the ventilator when this should have been possible. In 21 cases, ventilation was discontinued too soon when there was a chance that further treatment would have proved effective. In 10 cases it was felt to have been an inappropriate treatment in the first place and in 11, ventilation was discontinued due to patient intolerance.

Table 6.26 NIV discontinued at the appropriate time – reviewers' opinion

	Number of patients	%
Yes	232	72.0
No	90	28.0
Subtotal	**322**	
Unknown	31	
Total	**353**	

NIV outcome

Overall, NIV was successful in 221/347 (63.7%) patients. In the group of 126/347 (36.3%) where NIV failed, 18 patients proceeded to intubation and invasive ventilation. In almost a quarter of all cases (86/347; 24.8%) treatment was withdrawn (Table 6.27).

Table 6.27 Outcome of NIV

	Number of patients	%
Success: (clinical improvement with normalisation of pH to >7.35)	198	57.1
Success: (clinical improvement/ cessation of NIV: no blood gas confirmation)	23	6.6
Failure: (remained acidotic pH<7.35 AND hypercapnic CO_2>6kPa)	22	6.3
Failure: and proceeded to intubation	18	5.2
Failure: treatment withdrawn	86	24.8
Subtotal	**347**	
Not answered	6	
Total	**353**	

In some cases, where the ceiling of treatment has been defined as NIV without escalation to invasive ventilation, a trial of NIV can be reasonable even when it is likely to fail. In these situations it is particularly important to ensure that delivery of NIV is optimal and senior decision makers are involved. When NIV was not successful, reviewers found that in 77/106 cases (72.6%) this was predictable (Table 6.28).

Table 6.28 NIV failure was predictable – reviewers' opinion

	Number of patients	%
Yes	77	72.6
No	29	27.4
Subtotal	**106**	
Unknown	20	
Total	**126**	

Where failure was predictable, however the reviewers considered that in half of these cases it was still an appropriate intervention. In cases of NIV failure, where this was not predictable, reviewers found that it was appropriate in 27/28 cases (Table 6.29)

Table 6.30 shows that in patients with higher frailty scores (6-9; moderate frailty or greater), NIV was more likely to be unsuccessful. NIV was successful in 113/202 (55.9%) patients with higher frailty scores compared with 98/132 (74.2%) patients with scores in the lower range (Rockwood score 1-5).

Table 6.29 NIV failure predictable versus appropriateness of NIV as an intervention – reviewers' opinion

	NIV an appropriate intervention				
NIV failure predictable	**Yes**	**No**	**Subtotal**	**Not answered**	**Total**
Yes	35	42	**77**	0	**77**
No	27	1	**28**	1	**29**
Subtotal	**62**	**43**	**105**	**1**	**106**
Unknown	15	4	**19**	1	**20**
Total	**77**	**47**	**124**	**2**	**126**

Table 6.30 Success or failure of NIV compared with frailty

	NIV				
Rockwood score	**Success**	**Failure**	**Subtotal**	**Not answered**	**Total**
1-5	98	34	**132**	4	**136**
6-9	113	89	**202**	2	**204**
Subtotal	**211**	**123**	**334**	**6**	**340**
Not answered	10	3	**13**	0	**13**
Total	**221**	**126**	**347**	**6**	**353**

Table 6.31 Overall appropriateness of ventilator settings – reviewers' opinion

	Subsequent ventilator management appropriate				
Initial ventilator settings appropriate	**Yes**	**No**	**Subtotal**	**Unknown**	**Total**
Yes	152	56	**208**	28	**236**
No	23	33	**56**	3	**59**
Subtotal	**175**	**89**	**264**	**31**	**295**
Unknown	13	11	**24**	34	**58**
Total	**188**	**100**	**288**	**65**	**353**

Assessment of NIV care

When the reviewers' assessment of initial NIV settings and subsequent management were combined there were 112/264 (42.4%) patients where some aspect of ventilator management was found not to be appropriate (Table 6.31) and there was room for improvement in decision making about ventilator management in 174/288 (60.4%) cases reviewed (Table 6.32).

Table 6.32 Room for improvement in decision making about ventilator management – reviewers' opinion

	Number of patients	%
Yes	174	60.4
No	114	39.6
Subtotal	**288**	
Unknown	65	
Total	**353**	

On review of the case notes and questionnaires, both the case reviewers (73.0%) and the clinicians who looked after the patients (48.6%) found aspects of NIV treatment that could have been improved in a high proportion of cases (Table 6.33).

Table 6.33 Any aspects of NIV treatment that could have been improved

	Reviewers' opinion		Clinicians' opinion	
	Number of patients	%	Number of patients	%
Yes	232	73.0	162	48.6
No	86	27.0	171	51.4
Subtotal	**318**		**333**	
Unknown	35		99	
Total	**353**		**432**	

CASE STUDY 8

A patient with a COPD exacerbation was admitted with acute ventilatory failure. NIV was started appropriately within three hours of admission. The patient improved over the first 48 hours and blood gases showed resolution of the acidosis. NIV was only stopped four days later on the consultant ward round. The patient was discharged home two days later.

Reviewers considered that NIV could have been stopped sooner and that continuing NIV treatment delayed discharge planning.

The specific areas they identified are those already highlighted in this chapter, namely poor documentation and monitoring, delay in treatment and inadequate pressure titration (Table 6.34).

Table 6.34 Areas for improvement in NIV care

	Reviewers' opinion	Clinicians' opinion
Documentation	65	39
Pressure titration	49	17
Delay	1	23
Oxygen treatment	6	8
Monitoring (arterial blood gas)	10	5
Senior review	7	2
Inappropriate use	1	10

Answers may be multiple

Overall quality of acute NIV care

The reviewers rated the overall quality of NIV provided as good in 94/342 (27.5%) patients, adequate in 166/342 (48.5%) and as poor or unacceptable in 82/342 (24.0%) patients (Figure 6.17).

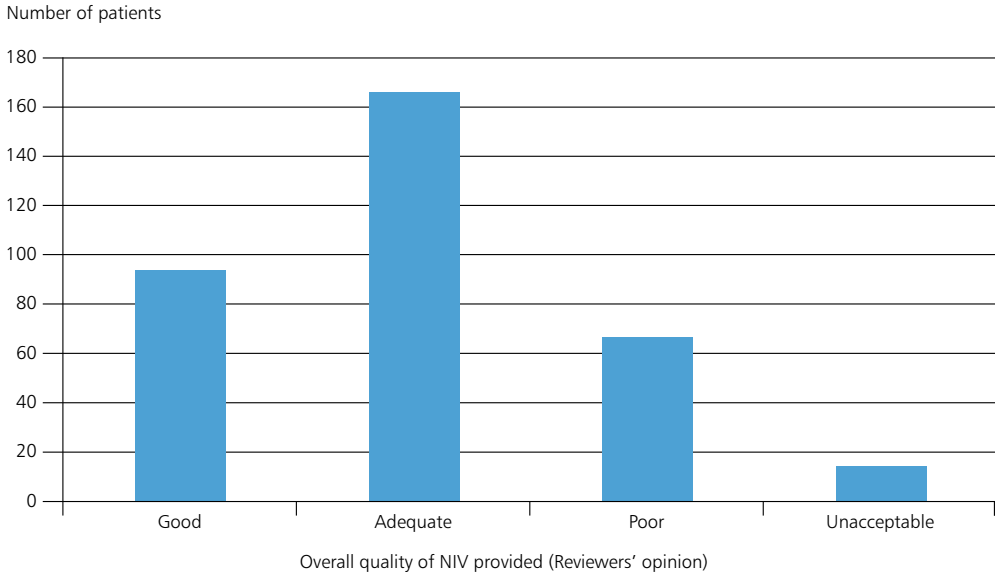

Figure 6.17 Overall quality of NIV provided

6

Key Findings

- There was a delay in starting NIV in 96/350 (27.4%) patients in the view of the reviewers and in 63/420 (15.0%) in the view of the clinicians
- For 88/156 (56.4%) patients who started NIV in the emergency department, their pH was below 7.26 and there was a sub-group (28/88) who were suffering from oxygen toxicity
- 66/150 (44.0%) patients were treated on acute medical units, respiratory or general wards with a starting pH <7.26 and in 56/150 (37.3%) patients treatment was continued in a general ward area despite a high risk of treatment failure and guidelines that recommend a higher level of care
- In 180/350 (51.4%) of the cases reviewed, ventilator settings were not adequately documented
- Despite the severity of illness, the frequency of documentation of vital signs was not appropriate in over a third (104/311; 33.4%) of patients
- Blood gas sampling was too infrequent in almost a third of cases (107/331; 32.3%)
- The ongoing ventilator management after initial set up was not appropriate in 100/288 (34.7%) cases
- There were signs of deterioration on NIV in 145/345 (42.0%) patients. The most common feature was worsening acidosis which occurred in 70 of the patients
- In the majority of cases (100/145; 69%) clinical deterioration resulted in clinical review of the patient
- There did not appear to be a difference in the pH response to ventilation during the first four hours of treatment between the patients who survived and those who died
- In those patients who survived the average pH at initiation of NIV was 7.247, rising to an average of 7.402 which reflected success of ventilation in correcting the acidosis
- In patients who died, the average starting pH was 7.261. In this group, the pH failed to correct and the final pH on stopping NIV remained below normal at 7.317
- The average time to correct the acidosis was just under 22 hours for 148 patients where pH values were available for both time points
- In survivors, the average respiratory rate improved in treatment from 25 to 21 (114 patients)
- In patients who died, the average respiratory rate was 29 at the beginning of the NIV episode and 26 when NIV was discontinued (43 patients)
- 28/184 (15.2%) patients had an initial heart rate of more than 120 beats per minute at the start of the episode. Current guidelines recommend continuous ECG monitoring for this group
- In 90/322 (28%) patients, the reviewers felt that ventilation was not discontinued at an appropriate time
- NIV was successful in 221/347 (63.7%) patients. In the group of 126/347 (36.3%) where NIV failed, 18 patients proceeded to intubation and invasive ventilation. In almost a quarter of all cases (86/347; 24.8%) treatment was withdrawn
- Overall 112/264 (42.4%) patients had some aspect of ventilator management which was found not to be appropriate
- There was room for improvement in decision making about ventilator management in 174/288 (60.4%) cases reviewed.

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7

Escalation and critical care

Up to 20% of cases of acute hypercapnic respiratory failure will require treatment in critical care.[7] Enhanced staffing for patients receiving non-invasive ventilation (NIV) is associated with reduced mortality rates.[25,26] NIV treatment failure, in particular when this occurs several hours after treatment has been started, is also associated with a higher mortality rate.[3,21] Clinical parameters associated with treatment failure include reduced conscious level, respiratory rate above 30 per minute and pH less than 7.25.

All patients commencing NIV treatment should therefore have a plan made for the appropriate level of escalation in the event of treatment failure. Data here show that often this does not happen. This is consistent with the findings of previously published data where documented escalation plans were found in 60-74% of cases.[3,17]

In the 77 cases where reviewers felt that NIV treatment failure was predictable, 26 patients had no treatment escalation plan in place. There were also 70 patients who developed a worsening acidosis, while on NIV. Of these, there were 20 where the reviewers were of the view that intubation was appropriate (Table 7.1). In 13 of these 20 cases, intubation was considered by the clinical team looking after the patient.

Table 7.1 Intubation was appropriate where acidosis was worsening – reviewers' opinion

	Number of patients	%
Yes	20	29.9
No	47	70.1
Subtotal	**67**	
Not answered	3	
Total	**70**	

In the 2013 national NIV audit only 3% of cases included were intubated and ventilated. This led to the suggestion that some patients may be denied escalation and treatment in critical care units or denied intubation where this was indicated. In the peer reviewed cases in this study, 156/328 (47.6%) patients were referred to critical care (Table 7.2).

Table 7.2 Critical care referral

	Number of patients	%
Yes	156	47.6
No	172	52.4
Subtotal	**328**	
Not answered	25	
Total	**353**	

Referrals were generally made at the appropriate time and of the 156 patients referred, 103/149 (69.1%) were admitted but there were 6 patients not admitted to a critical care unit who case reviewers felt might have benefited (data not shown).

Six patients were admitted to critical care due to a lack of beds on the NIV ward/unit (Table 7.3). This suggests good working relationships between the critical care and NIV services allowing for flexible use of beds to increase NIV capacity.

Table 7.3 Referral to critical care – reviewers' opinion

	Number of patients	%
Appropriate time	119	79.9
Too late	16	10.7
Due to lack of NIV beds	6	4.0
Inappropriate	7	4.7
Too early	1	<1
Subtotal	**149**	
Not answered	7	
Total	**156**	

In the 46 patients who were referred but not admitted to critical care, the most common reason given was frailty (Table 7.4).

Table 7.4 Reasons for not admitting referred patients to critical care

	Number of patients
Frailty	12
Inappropriate (palliative care needed)	5
Lack of beds	7
Diagnosis	10
No reason given	4
Other	21

Answers may be multiple; n=46

Figure 7.1 shows the Rockwood clinical frailty score for patients admitted to critical care, referred but not admitted and those not referred. In the patients not referred to critical care, 117/165 (70.9%) had a frailty score of 6 (moderately frail) or higher. In the group referred to critical care, 68/144 (47.2%) had a score in this range.

In the group referred to critical care, 35/150 (23.3%) had a frailty score of 1-3 (very fit, well, managing well) whereas only 13/165 (7.9%) of the group not referred had this level of fitness. This suggests that frailty was an important factor in decision making about referral and admission to critical care.

Of the patients admitted to critical care, 91 received NIV and 18 were intubated. This gave an overall intubation rate of 5.1% (18/353) in the peer reviewed cases.

For patients with a pH of less than 7.25 on initiation of NIV, critical care is the recommended environment. Table 7.5 shows that 87/184 (47.3%) patients with a pH in this range were referred to critical care. In the group with a higher pH of 7.26 or above, where care in a ward environment is more appropriate, a slightly lower proportion (92/217; 42.4%) were referred to critical care.

There was a group of 36 patients where the reviewers considered that the initial acidosis was so severe that intubation would have been appropriate. Of these, 14/36 were not referred to critical care.

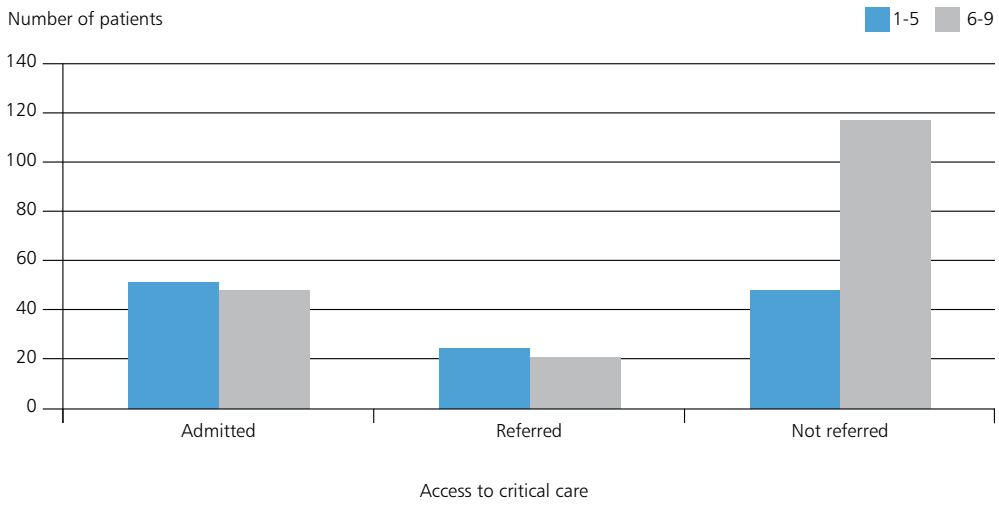

Figure 7.1 Rockwood clinical frailty 1-5 and 6-9 vs group admitted/referred/not referred to critical care

Table 7.5 pH range and referral to critical care

	Patient referred to critical care				
pH at start of NIV	**Yes**	**No**	**Subtotal**	**Not answered**	**Total**
< 7.26	87	97	**184**	3	**187**
≥ 7.26	92	125	**217**	5	**222**
Total	**179**	**222**	**401**	**8**	**409**

In the critical care unit, 78 patients had an arterial line inserted for invasive monitoring and/or blood gas sampling (Table 7.6).

Table 7.6 Interventions in critical care

	Number of patients
NIV	91
Arterial line	78
Intubation	18

Answers may be multiple; n=103

Table 7.7 shows that of the patients admitted to critical care, 26/92 died in the critical care unit, 3 patients were discharged directly home on NIV. Sixty-three patients were discharged back to a ward and of these, 10 were discharged on NIV (data not shown). Of the 63 patients discharged to the ward, 58 were ultimately discharged home.

Table 7.7 Outcome from critical care

	Number of patients
Discharged to ward	63
Discharged home on NIV	3
Died	26
Subtotal	**92**
Not answered	11
Total	**103**

Key Findings

- 156/328 (47.6%) patients were referred to critical care
- In 77 cases where reviewers felt that NIV treatment failure was predictable, 26 patients had no treatment escalation plan in place
- In 36 patients the reviewers considered that the initial acidosis was so severe that intubation would have been appropriate. Of these, 14/36 were not referred to critical care
- 68/144 (47.2%) patients referred to critical care had a frailty score of 6 (moderately frail) or higher. In the patients not referred to critical care, 117/165 (70.9%) had a frailty score in this range
- Of the patients admitted to critical care, 91 received NIV and 18 were intubated. This gave an overall intubation rate of 5.1% (18/353) in the peer reviewed cases
- Of the patients admitted to critical care, 26/92 died in the critical care unit, 3 patients were discharged directly home on NIV, 63 patients were discharged back to a ward and of these, 10 were discharged on NIV.

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8

Discharge, follow-up and advance care planning

The population of patients treated acutely with NIV has a high incidence of comorbid conditions and the Rockwood clinical frailty scores presented earlier show that more than half of the patients in this study were moderately frail or worse prior to hospital admission. Discharge from hospital can therefore be complex with a high risk of readmission and need for further NIV.

High quality care includes the management of co-morbidities and consideration of symptom control, alongside treatment of the primary condition requiring NIV which may need assessment of the need for long term ventilatory support. Specialist respiratory in-patient review and follow-up is important to ensure appropriate management and reduce readmissions.

Hospital discharge

A total of 31/432 (7.2%) patients were discharged on NIV. There were 38/217 (17.5%) patients where the discharge from hospital was delayed and in three of these, the delay was caused by the need to wait for treatment with NIV to be set up at home (Table 8.1)

Table 8.1 Delay in discharge – reviewers' opinion

	Number of patients	%
No	179	82.5
Yes	38	17.5
Subtotal	**217**	
Not answered	4	
Total	**221**	

Follow-up

In patients who survived, the discharge summary did not include arrangements for follow-up in 44/176 (25.0%) cases (data not shown).

Table 8.2 shows that follow-up arrangements were made in two thirds of cases (171/266; 64.3%). Where it was documented, the follow-up that was arranged did not take place in over a third of cases (50/145; 34.5%) (Table 8.3). Almost one in six patients (49/270; 18.1%) were readmitted within 30 days of discharge (data not shown).

Table 8.2 Follow-up appointment arranged

	Number of patients	%
Yes	171	64.3
No	95	35.7
Subtotal	**266**	
Not answered	12	
Total	**278**	

Table 8.3 Follow-up appointment occurred

	Number of patients	%
Yes	95	65.5
No	50	34.5
Subtotal	**145**	
Not answered	26	
Total	**171**	

Advance planning, end of life and palliative care

Many patients treated acutely with NIV have complex long term conditions with persistent symptoms and some will be reaching the end of their life. Involvement of palliative care services has the potential to improve care for these patients, to improve symptom control in survivors and to help deliver high quality end of life care for those who die.

Of the 117 patients who died during the admission 13 (11.8%) were still being treated with NIV at the time of death (Table 8.4).

Table 8.4 Patient was being treated with NIV at time of death

	Number of patients	%
Yes	13	11.8
No	97	88.2
Subtotal	**110**	
Unknown	7	
Total	**117**	

CASE STUDY 9

A frail elderly patient was admitted with COPD and acute ventilatory failure. A plan for ward based NIV as the ceiling of treatment was made. The patient's family were involved in decision making and the palliative care team was involved from the outset. This facilitated good end of life care when it became clear that treatment was failing and was withdrawn 48 hours later.

The reviewers considered this was an example of good practice in particular commenting on the standard of documentation, involvement of the family and good use of palliative care.

Reviewers found that in the majority (100/111; 90.1%) of deaths, treatment was limited or withdrawn prior to death (Table 8.5). Reviewers felt that this decision was appropriate in 89/95 (93.7%) where they were able to comment.

Table 8.5 Treatment was limited or withdrawn prior to death

	Number of patients	%
Yes	100	90.1
No	11	9.9
Subtotal	**111**	
Unknown	6	
Total	**117**	

When treatment is withdrawn, there is an opportunity to involve the palliative care team in ongoing care. No data were collected on the time between withdrawal of treatment and death but palliative care services were rarely involved in the care of patients who received NIV. In the patients who died, the palliative care team was involved in 12/85 cases where the reviewers were able to comment (Table 8.6). In an additional 43 patients who died, the reviewers considered that the palliative care team should have been involved; meaning that in total palliative care involvement would have been of benefit in 55/85 patients who died and where the reviewers were able to comment.

Table 8.6 Palliative care team involvement during the admission by outcome

	Discharged alive		Died in hospital	
Palliative care team involved during admission	**Number of patients**	**%**	**Number of patients**	**%**
Yes	11	5.2	12	14.1
No	201	94.8	73	85.9
Subtotal	**212**		**85**	
Unknown	9		32	
Total	**221**		**117**	

In survivors, the palliative care team was involved in the care of 11 patients. In survivors, the reviewers considered that palliative care involvement would have been of benefit in an additional 33 cases.

The point of discharge from hospital represents an opportunity to plan ahead for future use of NIV and other interventions. Conversations both at this point and at subsequent outpatient appointments might identify patients who would not want further hospital admissions or treatment with NIV. Shared decision making and advance care planning may be appropriate at this stage.

In 199/217 of the reviewed cases (91.7%), no documented decision was made about future use of NIV (Table 8.7). Similarly in only a small number (24/217; 11.1%) of cases was an advance care plan documented prior to discharge (Table 8.8).

Table 8.7 Documented decision about appropriateness of future NIV

	Number of patients	%
Yes - for NIV	12	5.5
Yes - not for NIV	6	2.8
No	199	91.7
Subtotal	**217**	
Not answered	4	
Total	**221**	

Table 8.8 Advance care plan documented prior to discharge

	Number of patients	%
Yes	24	11.1
No	193	88.9
Subtotal	**217**	
Not answered	4	
Total	**221**	

As already noted, outpatient follow-up was arranged in over two thirds of patients on discharge. This represents another opportunity to have a planned discussion about patient wishes for future treatments.

Key Findings

- 31/432 (7.2%) patients were discharged on NIV
- In patients who survived, the discharge summary did not include arrangements for follow-up in 44/176 (25.0%) cases
- Follow-up arrangements were made in two thirds of cases (171/266; 64.3%)
- Where documented, the follow-up that was arranged did not take place in over a third of cases (50/145; 35.7%)
- Almost one in six patients (49/270; 18.1%) were readmitted within 30 days of discharge
- In 199/217 of the reviewed cases (91.7%), no documented decision was made about future use of NIV
- In only a small number (24/217, 11.1%) of cases was an advance care plan documented prior to discharge.

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9

Mortality

National NIV audits over the last three cycles have shown worsening mortality rates, rising most recently to 34%. Data from both the peer review of cases in this study (34.6%) and from the overall cohort of patients identified for the study (35.3%) show that the mortality rate may have risen further since the latest audit (Tables 9.1 and 9.2).

Table 9.1 Patient outcome of the peer reviewed cases

	Number of patients	%
Discharged alive	221	65.4
Died in hospital	117	34.6
Subtotal	**338**	
Not answered	15	
Total	**353**	

Table 9.2 Patient outcome of the total number of patients included in the study

	Number of patients	%
Transferred to another hospital	17	4.0
Still an inpatient at 30 days	4	0.9
Discharged home	237	55.8
Died	150	35.3
Other	17	4.0
Subtotal	**425**	
Unknown/not answered	7	
Total	**432**	

Data were also collected on 12 month follow-up. This outcome was commonly not given or not known but there were an additional 50 patients who died out of 162 cases where the long term outcome was given. This gives an overall one year outcome of at least 46.3% (200/432) mortality. This is similar to published UK data[1] but worse than rates reported in Europe.[27]

Mortality rates have been shown to vary depending on underlying diagnosis, severity of acidosis, and location in which NIV is initiated.[3] These and other factors are explored in more detail below.

There were only small numbers of patients with a diagnosis of cardiogenic pulmonary oedema, obesity hypoventilation and chest wall or neuromuscular disease. The largest diagnosis group was COPD and in-hospital mortality in this group was 25.1% (50/199) (Table 9.3). This still compares unfavourably with the original studies that demonstrated the successful use of NIV on hospital wards where mortality was reduced from 20% to 10%.[1]

The pH criteria for entry into this study were however limited to patients with a mild acidosis (pH 7.25-7.35). The outcome for patients with a pH in the 7.26-7.35 range in this study was a mortality rate of 25.8% (39/151) for all cases and 18.7% (20/107) in the COPD group.

Table 9.3 Indication for NIV

	Discharged alive	Died in hospital	Mortality %	Subtotal	Not answered	Total
Chronic obstructive pulmonary disease	149	50	25.1	**199**	8	**207**
Other	17	25	59.5	**42**	3	**45**
Cardiogenic pulmonary oedema	15	12	44.4	**27**	1	**28**
Obesity/hypoventilation syndrome	8	4	33.3	**12**	0	**12**
Chest wall/ Neuromuscular	4	6	60.0	**10**	1	**11**

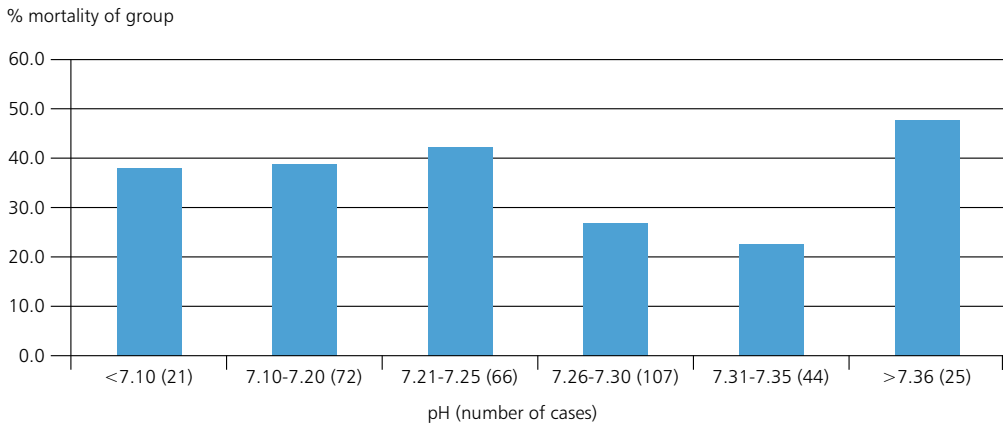

Figure 9.1 pH at initiation of NIV and mortality

At pH values below 7.26, the overall mortality rate following NIV was 40.3% (64/159). This supports the recommendation that patients treated with NIV whose pH falls into this range should be managed in a level 2 area.[6,7]

In the small number of cases where NIV was used with a normal or high pH, the mortality rate was 48% (12/25) (Figure 9.1). It is likely that in this group, although NIV was not indicated, clinical parameters meant that they were identified as sick and were at a higher risk of death.

Most patients are given appropriate treatment targeted at improving their underlying condition on admission to hospital. Deterioration despite appropriate treatment, selects for a group where outcome is worse. As a result patients admitted to critical care from acute admitting units have better outcomes than those admitted from general wards later in their hospital stay.

When NIV was initiated in the first 24 hours of admission, mortality was 25.1% (57/227). If it was used at a later stage of the admission, the mortality in this group was 55.4% (56/101) (Table 9.4).

Table 9.4 Outcome of patients who had NIV in the first 24 hours of admission

	NIV used in the first 24 hours						
	Yes		No				
Outcome	**Number of patients**	**%**	**Number of patients**	**%**	**Subtotal**	**Not answered**	**Total**
Discharged alive	170	74.9	45	44.6	**215**	6	**221**
Died in hospital	57	25.1	56	55.4	**113**	4	**117**
Subtotal	**227**		**101**		**328**	**10**	**338**
Not answered	8		5		**13**	2	**15**
Total	**235**		**106**		**341**	**12**	**353**

Similarly when analysing outcome by location of where NIV was started, initiation in the emergency department or the acute medical unit was associated with a mortality rate of 25% (42/168) and 31.5% (23/73) respectively. In other areas, the mortality rate was 40% or higher (Table 9.5).

Table 9.5 Outcome of patients versus location of NIV initiation

	Outcome			
Location of NIV	**Discharged alive**	**Died in hospital**	**Mortality (%)**	**Total**
Emergency department	126	42	25.0	**168**
Respiratory ward/designated NIV unit	51	37	42.0	**88**
Acute medical unit	50	23	31.5	**73**
Critical care	36	35	49.3	**71**
General ward	9	6	40.0	**15**
Other	7	3	30.0	**10**
Subtotal	**279**	**146**	**34.4**	**425**
Not answered	3	4	57.1	**7**
Total	**282**	**150**	**34.7**	**432**

It is likely that a sicker cohort of patients was admitted to critical care for NIV. For the 71 patients who started NIV in a critical care unit 35 died.

There was also a difference in outcome when patients with poor functional status on the Rockwood scale (moderately frail or greater) were compared with those with a lower score on the frailty scale. For patients with a better functional status (Rockwood score 1-5), 31/131 (23.7%) died. In the group who were moderately frail or worse (Rockwood score 6-9) 83/196 (42.4%) died (Table 9.6).

As noted in the chapter on response to ventilation, as a group, patients who died had on average higher respiratory rates and higher heart rates than those who survived and these improved with NIV treatment. A respiratory rate of 26 or above at the start of NIV was associated with a mortality rate of 37.5% (45/120 died) and a rate lower than 26 was associated with a mortality rate of 23.1% (31/134 died) (Table 9.7).

Table 9.6 Outcome of patients versus Rockwood clinical frailty score

	Outcome				
Rockwood score	**Discharged alive**	**Died in hospital**	**Subtotal**	**Not answered**	**Total**
1-5	100	31	**131**	5	**136**
6-9	113	83	**196**	8	**204**
Subtotal	**213**	**114**	**327**	**13**	**340**
Not answered	8	3	**11**	2	**13**
Total	**221**	**117**	**338**	**15**	**353**

Table 9.7 Outcome of patients versus initial respiratory rate

	Outcome					
Initial respiratory rate	**Discharged alive**	**Died in hospital**	**Mortality %**	**Subtotal**	**Not answered**	**Total**
<26	103	31	23.1	**134**	5	**139**
≥26	75	45	37.5	**120**	2	**122**
Total	**178**	**76**	**29.9**	**254**	**7**	**261**

Similarly, a heart rate of over 100 at the start of NIV was associated with a mortality rate of 39.3% (44/112 died). In patients with a lower heart rate of 100 or less, the mortality rate was 24.8% (33/133 died) (Table 9.8).

Data showing a worse outcome in the presence of pneumonia is presented in Chapter 10.

Finally, Table 9.9 shows that for patients where ventilator settings were not adequately documented there was a higher mortality rate, suggesting that, along with clinical factors, aspects of service organisation may also have an impact on mortality rates.

The data presented on mortality rates show that there was a substantial difference in outcome depending on case selection for NIV and on when and where treatment was started. A composite assessment of patient factors, underlying diagnosis and the degree of physiological derangement is needed to determine the best approach to treatment.

The factors that influenced survival rates in this study are summarised in Table 9.10. The presence of factors that are associated with an adverse impact on outcome from NIV should be considered when assessing the suitability of NIV as an intervention for individual patients, the location in which it should be provided and the staffing necessary to ensure the best outcome.

Table 9.8 Outcome of patients versus initial heart rate

	Outcome					
Initial heart rate	**Discharged alive**	**Died in hospital**	**Mortality %**	**Subtotal**	**Not answered**	**Total**
≤ 100	100	33	24.8	**133**	4	**137**
>100	68	44	39.3	**112**	3	**115**
Total	**168**	**77**	**31.4**	**245**	**7**	**252**

Table 9.9 Outcome of patients versus adequate ventilator settings

	Outcome					
Settings adequately documented	**Discharged alive**	**Died in hospital**	**Mortality %**	**Subtotal**	**Not answered**	**Total**
Yes	117	48	29.1	**165**	5	**170**
No	103	67	39.4	**170**	10	**180**
Subtotal	220	115		**335**	15	**350**
Not answered	1	2		**3**	0	**3**
Total	**221**	**117**	**34.3**	**338**	**15**	**353**

Table 9.10 Factors associated with mortality in patients treated with NIV

Better prognosis	Mortality (%)	Worse prognosis	Mortality (%)
Early NIV (<24 hrs)	25.1	Late NIV (>24 hrs)	55.4
Started in the emergency department or acute medical unit	27.0	Started in general/respiratory ward	41.7
Chronic obstructive pulmonary disease	25.1	Non-chronic obstructive pulmonary disease	49.0
Initial pH 7.26-7.35	25.8	Initial pH <7.26	40.3
pH ≥7.26 excluding O_2 toxicity	28.5	pH <7.26 excluding O_2 toxicity	45.3
Frailty score 1-5	23.7	Frailty score 6-9	42.3
Respiratory rate <26	23.1	Respiratory rate ≥26+	37.5
Heart rate <100	24.8	Heart rate ≥100+	39.3
No pneumonia	24.8	Pneumonia	44.4
Appropriate NIV	27.0	Inappropriate NIV	63.3
NIV success	5.9	NIV failure	81.7
Previous NIV	23.3	No previous NIV	36.6
Good documentation	29.1	Poor documentation	39.4

Key Findings

- Data from the peer review of cases in this study showed a mortality rate of 34.6% (117/338) and from the overall cohort of patients 35.3% (150/425)
- The largest diagnosis group was COPD and mortality in this group was 25.1% (50/199)
- The outcome for patients with a pH in the 7.26-7.35 range in this study was a mortality rate of 25.8% (39/151) for all cases and 18.7% (20/107) in the COPD group
- When NIV was initiated in the first 24 hours of admission, mortality was 25.1% (57/227). If it was used at a later stage of the admission, the mortality in this group was 55.4% (56/101)
- Initiation of NIV in the emergency department or the acute medical unit was associated with a mortality rate of 25% (42/168) and 31.5% (23/73) respectively. In other areas, the mortality rate was 40% or higher.

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10

Pneumonia

Respiratory failure is defined by either a failure of oxygenation (caused by poor matching of ventilation and perfusion in the lungs: 'type 1') or a failure of ventilation (reduced carbon dioxide elimination, due to failure of the respiratory muscle pump to generate an adequate breath: 'type 2'). Patients with pneumonia as a primary diagnosis, initially develop failure of oxygenation due to lung congestion. In severe cases, failure of ventilation can develop and is a sign of potentially life threatening disease.

Patients with other co-morbid conditions are at risk of developing lower respiratory tract infection. In particular, patients with COPD commonly present with infection as a feature of their acute exacerbation.

The most recent guidelines state that non-invasive ventilation (NIV) is not indicated in pneumonia and that patients should be referred to intensive care for consideration of invasive ventilation.[7] This raises important questions about the definition of pneumonia, which is more complex than the presence or absence of consolidation on an x-ray. It also raises questions about the appropriateness of NIV in patients where invasive ventilation is considered inappropriate due to other factors. In patients with COPD and minor x-ray changes who develop acute ventilatory failure, NIV remains an appropriate treatment.

In the peer reviewed cases there was evidence of pneumonia in just over half (177/351; 50.4%) of the cases. Data from the clinical questionnaire showed that in 166/408 (40.7%) cases there was consolidation on the chest x-ray (Table 10.1).

Table 10.1 Pneumonia and x-ray consolidation

	Evidence of pneumonia		Chest x-ray consolidation	
	Number of patients	%	Number of patients	%
Yes	177	50.4	166	40.7
No	174	49.6	242	59.3
Subtotal	**351**		**408**	
Unknown/ not answered	2		24	
Total	**353**		**432**	

A one degree Celsius rise in body temperature results in a 15-17% increase in CO_2 production. Fever associated with infections can therefore precipitate ventilatory failure in patients with limited respiratory reserves. In the cohort of patients included in this study, 50/414 (12.1%; data not shown) had a fever (temperature of 38ºC or above). Table 10.2 shows that reviewers thought that NIV was an appropriate intervention in three quarters of patients with pneumonia. This table also shows that reviewers were more likely (25.7% vs 12.1%) to consider that NIV was inappropriate when pneumonia was present.

Table 10.2 Evidence of pneumonia and appropriate use of NIV – reviewers' opinion

	NIV an appropriate intervention				
Evidence of pneumonia	**Yes**	**No**	**Subtotal**	**Not answered**	**Total**
Yes	130	45	**175**	2	**177**
No	153	21	**174**	0	**174**
Subtotal	**283**	**66**	**349**	**2**	**351**
Not answered	2	0	**2**	0	**2**
Total	**285**	**66**	**351**	**2**	**353**

In the peer reviewed cases where pneumonia was documented, a higher proportion (83/166; 50% vs 71/160; 44.4%) of patients were referred to critical care (Table 10.3). Of those referred, 57/78 (73.1%) with pneumonia were admitted compared with 45/70 (64.3%) without pneumonia (Table 10.4). Overall therefore, 57/166 (34.3%) patients with pneumonia were admitted to critical care. This compares with 45/160 (28.1%) of the cases without pneumonia.

National NIV audit data has shown that 40% of patients treated with NIV had evidence of consolidation on the chest X-ray and that this was associated with worse outcomes (43% vs 28% mortality).[3] This was also the case in the national COPD audit (30% vs 24% mortality).[17] In the cases included in this study there was also a higher mortality rate when there was evidence of pneumonia when compared with cases without pneumonia. Of the cases with pneumonia, 76/171 (44.4%) died compared with 41/165 (24.8%) without pneumonia (Table 10.5).

These data confirm the importance of the combination of acute ventilatory failure and chest x-ray consolidation in defining a group of patients with a high risk of death. Early senior review and escalation planning is essential to ensure these patients receive appropriate treatment in the correct location.

Table 10.3 Evidence of pneumonia and referral to critical care

	Patient referred to critical care				
Evidence of pneumonia	**Yes**	**No**	**Subtotal**	**Not answered**	**Total**
Yes	83	83	**166**	11	**177**
No	71	89	**160**	14	**174**
Subtotal	**154**	**172**	**326**	**25**	**351**
Not answered	2	0	**2**	0	**2**
Total	**156**	**172**	**328**	**25**	**353**

Table 10.4 Evidence of pneumonia and admission to critical care

	Patient admitted to critical care				
Evidence of pneumonia	**Yes**	**No**	**Subtotal**	**Not answered**	**Total**
Yes	57	21	**78**	5	**83**
No	45	25	**70**	1	**71**
Subtotal	**102**	**46**	**148**	**6**	**154**
Not answered	1	0	**1**	1	**2**
Total	**103**	**46**	**149**	**7**	**156**

Table 10.5 Evidence of pneumonia versus outcome

	Outcome					
Evidence of pneumonia	**Discharged alive**	**Died in hospital**	**Mortality %**	**Subtotal**	**Unknown**	**Total**
Yes	95	76	44.4	**171**	6	**177**
No	124	41	24.8	**165**	9	**174**
Subtotal	**219**	**117**		**336**	**15**	**351**
Not answered	2	0		**2**	0	**2**
Total	**221**	**117**		**338**	**15**	**353**

10

Key Findings

- In the peer reviewed cases there was evidence of pneumonia in just over half (177/351; 50.4%) of the cases
- Overall 57/166 (34.3%) patients with pneumonia were admitted to critical care. This compares with 45/160 (28.1%) of the cases without pneumonia
- 76/171 (44.4%) patients with pneumonia died compared with 41/165 (24.8%) without pneumonia
- In 130/175 (74.3%) patients who had pneumonia, reviews considered the NIV was an appropriate treatment.

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11

Governance arrangements for NIV services

The data presented in earlier chapters has shown that patients receiving NIV have a high risk of death and that there is much room for improvement in care. When the clinician responsible for the care of the patient reviewed care delivered in their own hospital for this study, they often identified areas for improvement.

Systems to ensure quality of care include mortality and morbidity review, audit, and incident reporting. The Royal Colleges recommend local mortality and morbidity meetings to learn from clinical practice and to improve care.[28,29] Of the 150 patients who died, only 30 had their care discussed in such a meeting. In only two of these cases was specific learning from this review reported by the clinician who completed the questionnaire.

Table 11.1 Patient's case was discussed at a morbidity and mortality meeting (hospital death)

	Number of patients	%
Yes	30	29.4
No	72	70.6
Sub total	**102**	
Not answered	48	
Total	**150**	

Of the 72 patients that had no mortality review documented, there were 19 further examples where reflection on the case for the purposes of this study led to the identification of areas for improvement (Table 11.2). The comments noted by the clinicians included the identification of oxygen toxicity, inappropriate use of NIV, poor documentation, referral to critical care and involvement of palliative care. These reflect the themes found throughout this report and illustrate the value of local review of practice.

Clinical audit and case reviews are recommended by the General Medical Council.[30] These provide a mechanism to monitor practice and clinical outcomes. Annual audit of

Table 11.2 Lessons learned from case review, where the patient was not assessed in a morbidity and mortality meeting – clinicians' opinion

	Number of patients
Yes	19
No	50
Sub total	**69**
Not answered	3
Total	**72**

NIV services is also recommended alongside a register of patients receiving NIV kept as part of a quality improvement cycle.[6]

Most (135/160; 84.4%) hospitals contributed to the latest British Thoracic Society audit of NIV in 2013 (Table 11.3). However, less than half (74/162; 45.7%) of hospitals audited their own NIV service annually as recommended (Table 11.4).

Table 11.3 Hospital contributed to the British Thoracic Society 2013 NIV audit

	Number of hospitals	%
Yes	135	84.4
No	25	15.6
Subtotal	**160**	
Not answered	8	
Total	**168**	

Table 11.4 Hospital undertakes annual audit of NIV service

	Number of hospitals	%
Yes	74	45.7
No	88	54.3
Subtotal	**162**	
Not answered	6	
Total	**168**	

As noted in Chapter 2, only 39/165 (23.6%) hospitals routinely collected data on the number of NIV episodes undertaken by their service. Lack of information on the number of treatment episodes makes service planning difficult. A fixed number of ventilators can treat the same fixed number of patients. It is of concern that 65/165 (39.4%) hospitals reported in the previous 12 months they had had times when they had more patients requiring NIV than machines available (Table 11.5).

Table 11.5 More patients than NIV machines

	Number of hospitals	%
Yes	65	39.4
No	100	60.6
Subtotal	**165**	
Not answered	3	
Total	**168**	

It is also of concern that 44/154 (28.6%) hospitals investigated serious incidents or safety events related to NIV in 2015 (Table 11.6). Free text answers outlining the themes of these investigations showed a total of over 50 separate incidents. The themes of these reflect the findings in this report. There were cases of delayed treatment, failure to escalate, unsupported junior staff making decisions and problems with oxygen administration. The most common theme however was poor outcome due to a lack of resources. There was an identified need to provide more timely care in an environment with both the equipment and staffing required to deliver high quality NIV.

Table 11.6 Hospital investigated serious incident related to NIV in 2015

	Number of hospitals	%
Yes	44	28.6
No	110	71.4
Subtotal	**154**	
Not answered	14	
Total	**168**	

CASE STUDY 10

A young patient with COPD was admitted to hospital with an exacerbation and moderate respiratory acidosis requiring NIV. The need for treatment was identified quickly but there were no beds available on the designated NIV unit and no ventilator was available. The patient was transferred immediately to the intensive care unit where mask ventilation was delivered using an ICU ventilator. The patient was transferred to the NIV unit the following day where NIV treatment was continued until they recovered.

The reviewers thought that this was an example of good practice with excellent team working and flexible use of resources to deliver care to the patient at the time it was needed.

Key Findings

- Of the 150 patients who died, only 30 had their care discussed at a morbidity and mortality meeting
- Most (135/160; 84.4%) hospitals contributed to the latest British Thoracic Society audit of NIV in 2013
- Fewer than half (74/162; 45.7%) of hospitals audited their own NIV service annually
- 65/165 (39.4%) hospitals reported in the previous 12 months that they had had times when they had more patients requiring NIV than machines available
- 44/154 (28.6%) hospitals investigated serious incidents or safety events related to NIV in 2015.

12

Overall quality of care and summary

Overall quality of care

The reviewers were asked to assign a grade to the overall care received by each patient in the study.

Overall care was rated as good in 67/347 (19.3%) cases. The reviewers judged that there was room for improvement in clinical and/or organisational care in a high proportion of patients, 254/347 (73.2%). There were 26 patients where the overall care was felt to be less than satisfactory (Table 12.1 and Figure 12.1)

Table 12.1 Overall quality of care – reviewers' opinion

	Number of patients	%
Good Practice	67	19.3
Room for improvement clinical	119	34.3
Room for improvement organisational	43	12.4
Room for improvement clinical and organisational	92	26.5
Less than satisfactory	26	7.5
Subtotal	**347**	
Insufficient data	6	
Total	**353**	

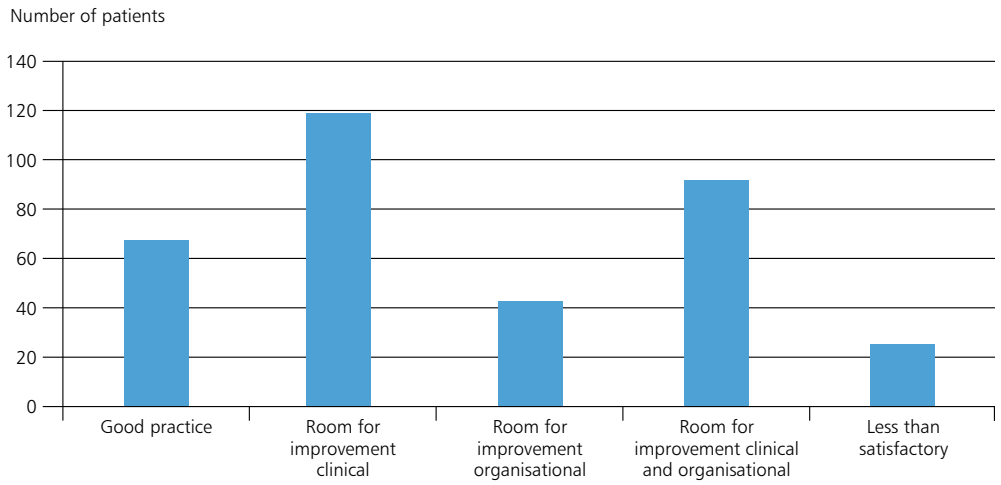

Figure 12.1 Overall quality of care – reviewers' opinion

Summary

The provision of effective care to patients with acute non-invasive ventilation is more complex than it first seems.

This study has shown that major improvements are required. The care of these patients was rated as less than good in four out of five cases. The mortality rate was high; more than one in three patients died.

Despite guidelines that recommend staffing levels and arrangements for monitoring patients treated with NIV, there was wide variation in how services were organised. Supervision of care and patient monitoring were commonly inadequate.

Case selection for NIV was often inappropriate, and treatment was frequently delayed due to a combination of service organisation and a failure to recognise that NIV was needed. The quality of medical care provided was often poor. This poor care included both non-ventilator treatments and ventilator management which were frequently inappropriate.

This study has also revealed the complexity involved in assessing an individual patient's response to NIV. This involves detailed vital signs monitoring, and blood gas analysis alongside an understanding of the effect of changes in ventilator settings and the overall goals of treatment. All aspects of this assessment were frequently poorly done or omitted entirely.

Both the reviewers who assessed the cases and the clinicians who looked after the patients in their own hospitals identified the same areas for improvement in care. Organisations regularly reported clinical incidents related to patients receiving NIV. Despite this they frequently did not audit their own practice.

In order to improve the outcome from NIV, organisations must act to ensure services are well designed, local leadership is in place and competent staff are available to deliver care. For clinicians, the importance of case selection, regular patient assessment, specialist involvement and the clinical factors that influence outcome needs to be emphasised.

Recommendations

The overarching purpose of these recommendations is to improve the quality of care provided to patients receiving acute non-invasive ventilation (NIV). Issues in relation to the timeliness, appropriateness, location, level of care and competency of staff treating patients with acute NIV have been highlighted.Those who should be primarily responsible for leading on the recommendations are listed in parentheses after each recommendation. These are NCEPOD's suggestions and can be extended to others as appropriate.

1. All hospitals should have a clinical lead for their acute non-invasive ventilation (NIV) service. The clinical lead should have time allocated in their job plan with clear objectives, including audit and governance for this service. *(Medical Directors and Nursing Directors)*

2. Continuous positive airways pressure (CPAP) and non-invasive ventilation (NIV) should be coded separately. They are two distinct treatments given for different conditions and separate coding will reduce clinical confusion and improve reporting of outcomes. *(NHS Digital and the Association of Clinical Coders)*

3. Acute non-invasive ventilation treatment should only be provided in clinical areas equipped with:
   a. Continuous pulse oximetry;
   b. Continuous ECG monitoring; and
   c. Rapid access to the results of blood gas analysis.
   (Medical Directors and Nursing Directors)

4. In line with current British Thoracic Society guidelines, patients with known chronic obstructive pulmonary disease, or other known risk factors for hypercapnic respiratory failure, should have an oxygen saturation of 88-92% maintained, both prior to admission and on admission to hospital. The device used for oxygen delivery, the concentration of oxygen administered and the target saturation should be documented in the relevant patient record. *(Ambulance Trusts and Emergency Medicine Physicians)*

5. Treatment with acute non-invasive ventilation (NIV) must be started within a maximum of one hour of the blood gas measurement that identified the need for it, regardless of the patient's location. A service model whereby the NIV machine is taken to the patient to start treatment prior to transfer for ongoing ventilation will improve access to acute NIV. *(All Clinical Staff Providing Acute Non-Invasive Ventilation and Acute Non-Invasive Ventilation Service Leads)*

6. In all areas providing acute non-invasive ventilation (NIV), a minimum staffing ratio of one nurse to two acute NIV patients must be in place, as recommended in the British Thoracic Society guideline. The duration for which this should continue will be determined by each individual patient's response to ventilation. *(Nursing Directors and Medical Directors)*

7. All hospitals where acute non-invasive ventilation (NIV) is provided must have an operational policy that includes, but is not limited to:
   a. Appropriate clinical areas where acute NIV can be provided, and in those areas the minimum safe level of staff competencies;
   b. Staff to acute NIV patient ratios;
   c. Escalation of treatment and step down care procedures;
   d. Standardised documentation; and
   e. Minimum frequency of clinical review, and seniority of reviewing clinician

   Compliance with this policy should be part of the annual audit process. *(Medical Directors, Nursing Directors and Acute Non-Invasive Ventilation Service Leads)*

   **See Appendix 1 – British Thoracic Society competency checklist www.brit-thoracic.org.uk/ standards-of-care/guidelines/ btsrcpics-guideline-for-non- invasive-ventilation/*

8. All staff who prescribe/make changes to acute non-invasive ventilation treatment must have the required level of competency as stated in their hospital operational policy. A list of competent staff should be maintained. *(Medical Directors and Nursing Directors)*
   **See Appendix 1 – British Thoracic Society competency checklist and NIV prescription chart*
   www.brit-thoracic.org.uk/ standards-of-care/guidelines/ btsrcpics-guideline-for-non- invasive-ventilation/

9. All patients treated with acute non-invasive ventilation (NIV) must have a treatment escalation plan in place prior to starting treatment. This should be considered part of the prescription for acute NIV and include plans in relation to:
   a. Escalation to critical care;
   b. Appropriateness of invasive ventilation; and
   c. Ceilings of treatment.

   This should take into account:
   d. The underlying diagnosis;
   e. The risk of acute NIV failure; and
   f. The overall management plan.

   (All Clinical Staff Responsible for Starting Acute NIV)
   **See Appendix 1 – British Thoracic Society NIV prescription chart*
   www.brit-thoracic.org.uk/ standards-of-care/guidelines/ btsrcpics-guideline-for-non- invasive-ventilation/

10. All patients treated with acute non-invasive ventilation (NIV) must be discussed with a specialist competent in the management of acute NIV at the time treatment is started or at the earliest opportunity afterwards. Consultant specialist review to plan ongoing treatment should take place within a maximum of 14 hours. *(Acute Non-Invasive Ventilation Service Leads)*

11. All patients receiving acute non-invasive ventilation (NIV) should receive, as a minimum, daily consultant review while they remain on ventilation. This consultant must be competent in acute NIV management. *(Clinical Directors and Consultants Responsible for Acute NIV)*

12. All patients treated with acute non-invasive ventilation must have their vital signs recorded at least hourly until the respiratory acidosis has resolved. A standardised approach such as the National Early Warning Score is recommended. *(Nurses and Acute Non-Invasive Ventilation Service Leads)*
    **See Appendix 3 – National Early Warning Score (NEWS)*
    www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news

13. Documentation of all changes to ventilator settings is essential and the use of a standardised proforma is recommended. *(Acute Non-Invasive Ventilation Service Leads)*
    **See Appendix 1 – British Thoracic Society NIV prescription and settings chart*
    www.brit-thoracic.org.uk/ standards-of-care/guidelines/ btsrcpics-guideline-for-non- invasive-ventilation/

14. The use of acute non-invasive ventilation could act as a flag to consider referral to palliative care services, as this may be valuable for both active symptom control and end of life care. *(Clinical Staff)*

15. Following an acute non-invasive ventilation episode, a structured plan for future treatment should be discussed with the patient and/or carer either at the point of discharge from hospital or at subsequent follow-up. This must be documented and a copy of the plan given to the patient and to the patient's general practitioner. *(Clinical Staff)*

16. In the absence of a recognised indication for acute non-invasive ventilation (e.g. chronic obstructive pulmonary disease) patients with acute ventilatory failure and evidence of pneumonia have a high risk of death and acute NIV should not be considered standard treatment. Escalation of treatment should be actively considered. There should be close liaison between senior members of the medical and critical care teams to agree the most appropriate approach to management. *(Consultants)*

17. Governance arrangements for acute non-invasive ventilation (NIV) services should be in place in all organisations that provide acute NIV treatment. These should include all disciplines and specialities involved in the delivery of NIV. Depending on the local service model, those involved in the governance of acute NIV services are likely to include medical, nursing and physiotherapy staff from Emergency Medicine, Acute Medicine, Respiratory Medicine and Critical Care. *(Medical Directors, Nursing Directors and Acute Non-Invasive Ventilation Service Leads)*

18. All acute non-invasive ventilation services should have a record kept of the number of patients treated, to aid service planning. *(Acute Non-Invasive Ventilation Service Leads)*

19. All acute non-invasive ventilation services should be audited annually. The audit results should be reported to the Hospital Board. *(Acute Non-Invasive Ventilation Service Leads and Medical Directors)*

20. All hospitals should monitor their acute non-invasive ventilation mortality rate and quality of acute NIV care. This should be reported at Board level. *(Chief Executives, Medical Directors, Nurse Directors and Acute Non-Invasive Ventilation Service Leads)*

21. A quality standard for acute non-invasive ventilation is required to facilitate quality improvement in acute non-invasive ventilation services. *(British Thoracic Society and Local Quality Improvement Leads)*

NCEPOD strongly encourages the establishment of quality improvement work both locally and nationally to target the issues identified by this study. A gap analysis table to start this is available at www.ncepod.org.uk/niv

Effective quality improvement initiatives and their results should be shared locally and nationally wherever possible. NCEPOD would support dissemination of this work at future NCEPOD report launches and in NCEPOD newsletters.

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Appendices

Glossary

Term	Abbreviation	Definition
Acidotic ventilatory failure		Respiratory acidosis is a condition that occurs when the lungs cannot remove enough of the carbon dioxide (CO_2) produced by the body. Excess CO_2 causes the pH of blood and other bodily fluids to decrease, making them too acidic.
Alert, Voice, Pain, Unresponsive	AVPU	The AVPU scale (Alert, Voice, Pain, Unresponsive) is a system, which is taught to healthcare professionals on how to measure and record the patient's level of consciousness. It is a simplification of the GCS Scale (Glasgow Coma) which assesses a patient's response using eye opening, verbal and motor responses as measures.
Alveolar hypoventilation syndrome		This is defined as insufficient ventilation leading to hypercapnia.
Arterial blood gas	ABG	An arterial blood gas (ABG) test measures the acidity (pH) and the levels of oxygen and carbon dioxide in the blood from an artery.
Arterial line		An arterial line is a thin catheter inserted into an artery. It is most commonly used in intensive care medicine and anaesthesia to monitor blood pressure directly and in real-time. It can also be used when repeated blood sampling is indicated.
Carbon dioxide	CO_2	The gaseous waste product of metabolism. Normal range is 4.7-6.0 kPa.
Chronic obstructive pulmonary disease	COPD	This is a type of obstructive lung disease characterised by long-term poor airflow. The main symptoms include shortness of breath and cough with sputum production. COPD is a progressive disease, meaning it typically worsens over time.
Continuous positive airways pressure	CPAP	This refers to pressure applied to the lungs throughout both inspiration and expiration. It is used as a splint to keep the airways open.
Forced expiratory volume	FEV_1	This measures the amount of air a person can exhale during the first second of a forced breath. The value is reduced in many lung diseases, in particular COPD.
Hypercapnia		This is when excessive carbon dioxide collects in the blood stream.
Intermittent positive pressure ventilation	IPPV	Use of a mechanical respirator to deliver a controlled pressure of a gas to assist in ventilation or expansion of the lungs.

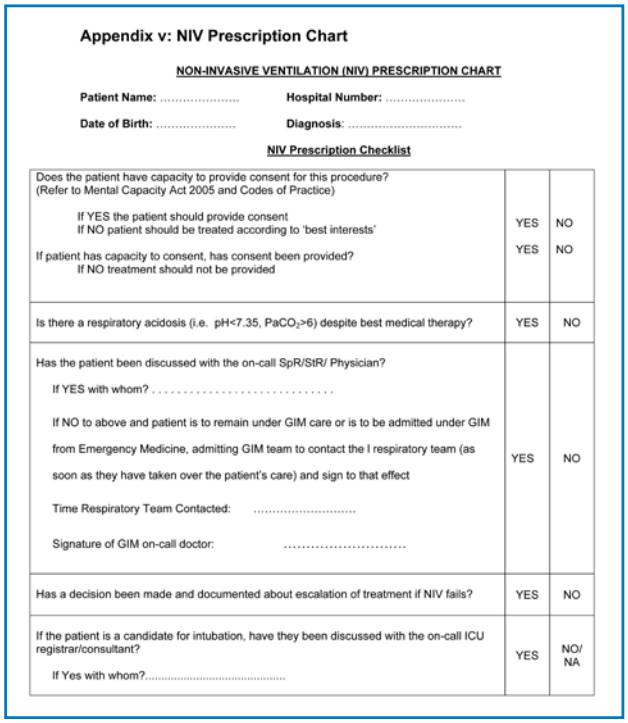
Intubation		Insertion of a tube into the trachea for ventilation.
Nasal cannulae		A device used to deliver supplemental oxygen.
Negative pressure ventilation	NPV	A form of medical ventilator that enables a person to breathe when normal muscle control has been lost or the work of breathing exceeds the person's ability.
Non-invasive ventilation	NIV	The provision of ventilatory support through the patient's upper airway using a mask or similar device. This technique is distinguished from those which bypass the upper airway with a tracheal tube, laryngeal mask, or tracheostomy and are therefore considered invasive.
Oxygen saturation		This is measured as a percentage of haemoglobin molecules that have oxygen attached to them to carry oxygen in the blood. Normal range is 95-100%.
Oxygen toxicity		Inspiration of too much oxygen.
Peak inspiratory pressure		This is the highest level of pressure applied to the lungs during inhalation. In mechanical ventilation the number reflects a positive pressure in centimeters of water pressure (cmH_2O).
pH		A scale to state how acidic or alkaline a substance is. Normal range is 7.35-7.44.
Pnemonia		Pneumonia is swelling (inflammation) of the tissue in one or both lungs.
Pulmonary oedema		An accumulation of fluid in the tissue and air spaces of the lungs.
Respiratory failure		Respiratory failure results from inadequate gas exchange by the respiratory system, meaning that the arterial oxygen, carbon dioxide or both cannot be kept at normal levels. A drop in the oxygen carried in blood is known as hypoxemia; a rise in arterial carbon dioxide levels is called hypercapnia.
Respiratory rate		The number of breaths per minute or, more formally, the number of movements indicative of inspiration and expiration per unit time.
Triage		The assignment of degrees of urgency to wounds or illnesses to decide the order of treatment of a large number of patients.
Venturi mask		A medical device to deliver a known oxygen concentration to patients on controlled oxygen therapy.

Appendix 1 - Standardised proformas for NIV

These figures are reproduced from the BTS/RCP/ICS Guideline: The Use of Non-Invasive Ventilation in the management of patients with chronic obstructive pulmonary disease admitted to hospital with acute type II respiratory failure (With particular reference to Bilevel positive pressure ventilation) by kind permission of the British Thoracic Society.

British Thoracic Society (BTS)/Royal College of Physicians London (RCP)/ Intensive Care Society (ICS): The Use of Non-Invasive Ventilation in the management of patients with chronic obstructive pulmonary disease admitted to hospital with acute type II respiratory failure (With particular reference to Bilevel positive pressure ventilation), October 2008.

The NIV prescription form is currently under review by the British Thoracic Society - more information is available from: https://www.brit-thoracic.org.uk/standards-of-care/quality-standards/bts-niv-quality-standards/



Appendix v: NIV Prescription Chart

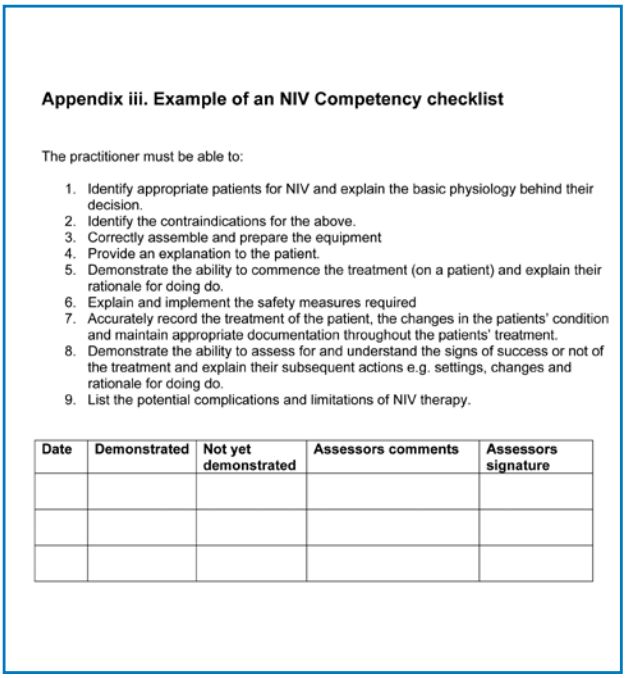
NON-INVASIVE VENTILATION (NIV) PRESCRIPTION CHART

Patient Name: ..... **Hospital Number:** .....

Date of Birth: ..... **Diagnosis**: .....

NIV Prescription Checklist

Does the patient have capacity to provide consent for this procedure? (Refer to Mental Capacity Act 2005 and Codes of Practice) If YES the patient should provide consent If NO patient should be treated according to 'best interests' If patient has capacity to consent, has consent been provided? If NO treatment should not be provided	YES YES	NO NO
Is there a respiratory acidosis (i.e. pH<7.35, $PaCO_2$>6) despite best medical therapy?	YES	NO
Has the patient been discussed with the on-call SpR/StR/ Physician? If YES with whom? ..... If NO to above and patient is to remain under GIM care or is to be admitted under GIM from Emergency Medicine, admitting GIM team to contact the I respiratory team (as soon as they have taken over the patient's care) and sign to that effect Time Respiratory Team Contacted: ..... Signature of GIM on-call doctor:	YES	NO
Has a decision been made and documented about escalation of treatment if NIV fails?	YES	NO
If the patient is a candidate for intubation, have they been discussed with the on-call ICU registrar/consultant? If Yes with whom?.....	YES	NO/ NA

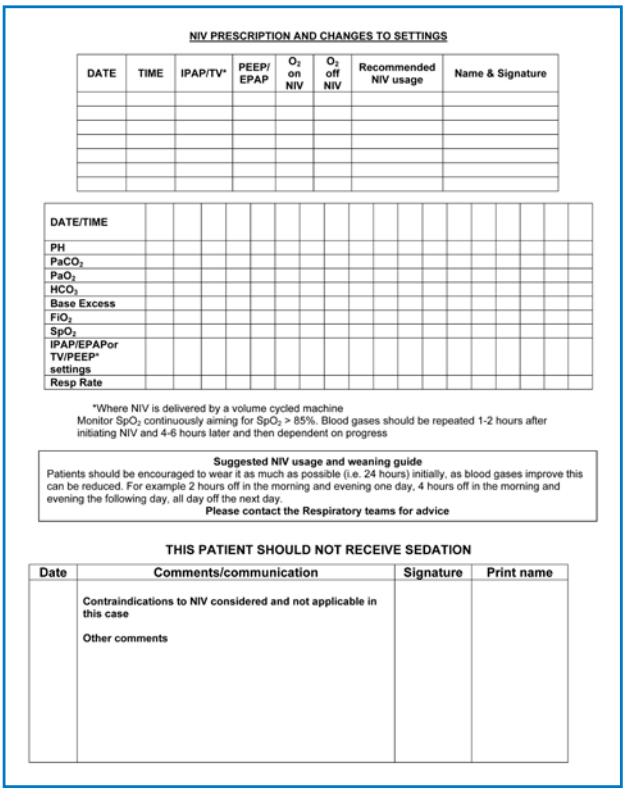


Appendix iii. Example of an NIV Competency checklist

The practitioner must be able to:

1. Identify appropriate patients for NIV and explain the basic physiology behind their decision.
2. Identify the contraindications for the above.
3. Correctly assemble and prepare the equipment
4. Provide an explanation to the patient.
5. Demonstrate the ability to commence the treatment (on a patient) and explain their rationale for doing do.
6. Explain and implement the safety measures required
7. Accurately record the treatment of the patient, the changes in the patients' condition and maintain appropriate documentation throughout the patients' treatment.
8. Demonstrate the ability to assess for and understand the signs of success or not of the treatment and explain their subsequent actions e.g. settings, changes and rationale for doing do.
9. List the potential complications and limitations of NIV therapy.

Date	Demonstrated	Not yet demonstrated	Assessors comments	Assessors signature



NIV PRESCRIPTION AND CHANGES TO SETTINGS

DATE	TIME	IPAP/TV*	PEEP/ EPAP	O_2 on NIV	O_2 off NIV	Recommended NIV usage	Name & Signature

DATE/TIME																		
PH																		
$PaCO_2$																		
PaO_2																		
HCO_3																		
Base Excess																		
FiO_2																		
SpO_2																		
IPAP/EPAPor TV/PEEP* settings																		
Resp Rate																		

*Where NIV is delivered by a volume cycled machine
Monitor SpO_2 continuously aiming for SpO_2 > 85%. Blood gases should be repeated 1-2 hours after initiating NIV and 4-6 hours later and then dependent on progress

Suggested NIV usage and weaning guide

Patients should be encouraged to wear it as much as possible (i.e. 24 hours) initially, as blood gases improve this can be reduced. For example 2 hours off in the morning and evening one day, 4 hours off in the morning and evening the following day, all day off the next day.

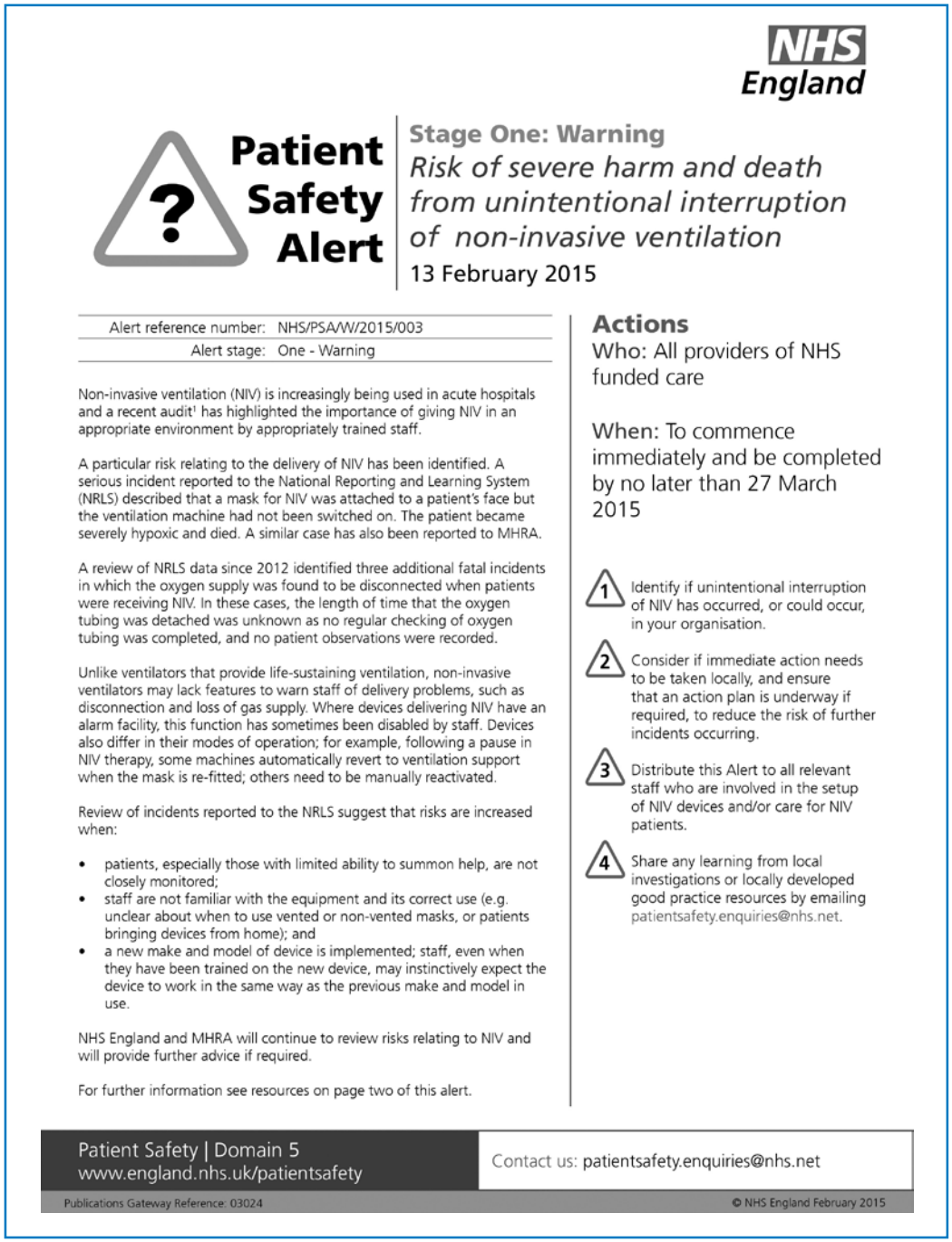
Please contact the Respiratory teams for advice

THIS PATIENT SHOULD NOT RECEIVE SEDATION

Date	Comments/communication	Signature	Print name
	Contraindications to NIV considered and not applicable in this case **Other comments**		

Appendix 2 – Patient safety alert. NHS England

https://www.england.nhs.uk/patientsafety/2015/02/16/psa-niv/



NHS England

Patient Safety Alert

Stage One: Warning

Risk of severe harm and death from unintentional interruption of non-invasive ventilation

13 February 2015

Alert reference number: NHS/PSA/W/2015/003
Alert stage: One - Warning

Non-invasive ventilation (NIV) is increasingly being used in acute hospitals and a recent audit[1] has highlighted the importance of giving NIV in an appropriate environment by appropriately trained staff.

A particular risk relating to the delivery of NIV has been identified. A serious incident reported to the National Reporting and Learning System (NRLS) described that a mask for NIV was attached to a patient's face but the ventilation machine had not been switched on. The patient became severely hypoxic and died. A similar case has also been reported to MHRA.

A review of NRLS data since 2012 identified three additional fatal incidents in which the oxygen supply was found to be disconnected when patients were receiving NIV. In these cases, the length of time that the oxygen tubing was detached was unknown as no regular checking of oxygen tubing was completed, and no patient observations were recorded.

Unlike ventilators that provide life-sustaining ventilation, non-invasive ventilators may lack features to warn staff of delivery problems, such as disconnection and loss of gas supply. Where devices delivering NIV have an alarm facility, this function has sometimes been disabled by staff. Devices also differ in their modes of operation; for example, following a pause in NIV therapy, some machines automatically revert to ventilation support when the mask is re-fitted; others need to be manually reactivated.

Review of incidents reported to the NRLS suggest that risks are increased when:

- patients, especially those with limited ability to summon help, are not closely monitored;
- staff are not familiar with the equipment and its correct use (e.g. unclear about when to use vented or non-vented masks, or patients bringing devices from home); and
- a new make and model of device is implemented; staff, even when they have been trained on the new device, may instinctively expect the device to work in the same way as the previous make and model in use.

NHS England and MHRA will continue to review risks relating to NIV and will provide further advice if required.

For further information see resources on page two of this alert.

Actions

Who: All providers of NHS funded care

When: To commence immediately and be completed by no later than 27 March 2015

1. Identify if unintentional interruption of NIV has occurred, or could occur, in your organisation.
2. Consider if immediate action needs to be taken locally, and ensure that an action plan is underway if required, to reduce the risk of further incidents occurring.
3. Distribute this Alert to all relevant staff who are involved in the setup of NIV devices and/or care for NIV patients.
4. Share any learning from local investigations or locally developed good practice resources by emailing patientsafety.enquiries@nhs.net.

Patient Safety | Domain 5
www.england.nhs.uk/patientsafety

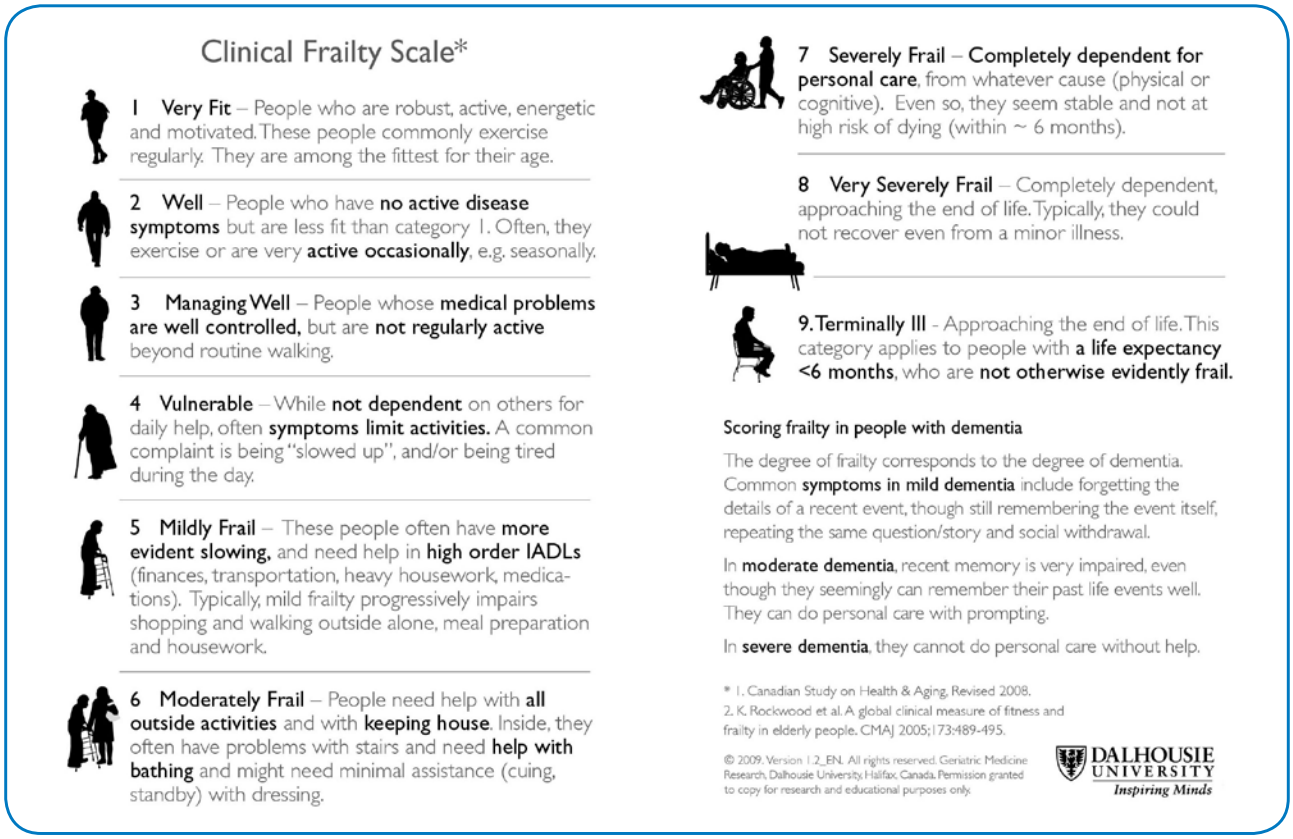
Contact us: patientsafety.enquiries@nhs.net

Publications Gateway Reference: 03024

Appendix 3 – Clinical Frailty Scale and Modified MRC Dyspnoea Scale

Rockwood Clinical Frailty Scale

K. Rockwood et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489-495



Clinical Frailty Scale*

1 **Very Fit** – People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age.

2 **Well** – People who have **no active disease symptoms** but are less fit than category 1. Often, they exercise or are very **active occasionally**, e.g. seasonally.

3 **Managing Well** – People whose **medical problems are well controlled,** but are **not regularly active** beyond routine walking.

4 **Vulnerable** – While **not dependent** on others for daily help, often **symptoms limit activities.** A common complaint is being "slowed up", and/or being tired during the day.

5 **Mildly Frail** – These people often have **more evident slowing,** and need help in **high order IADLs** (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework.

6 **Moderately Frail** – People need help with **all outside activities** and with **keeping house**. Inside, they often have problems with stairs and need **help with bathing** and might need minimal assistance (cuing, standby) with dressing.

7 **Severely Frail** – **Completely dependent for personal care**, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months).

8 **Very Severely Frail** – Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness.

9. **Terminally Ill** - Approaching the end of life. This category applies to people with **a life expectancy <6 months**, who are **not otherwise evidently frail.**

Scoring frailty in people with dementia

The degree of frailty corresponds to the degree of dementia. Common **symptoms in mild dementia** include forgetting the details of a recent event, though still remembering the event itself, repeating the same question/story and social withdrawal.

In **moderate dementia**, recent memory is very impaired, even though they seemingly can remember their past life events well. They can do personal care with prompting.

In **severe dementia**, they cannot do personal care without help.

* 1. Canadian Study on Health & Aging, Revised 2008.
2. K. Rockwood et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173:489-495.

DALHOUSIE UNIVERSITY *Inspiring Minds*

Modified Medical Research Council Dyspnoea (Breathlessness) Scale

Mahler DA, Wells CK. Evaluation of clinical methods for rating dyspnea. Chest 1988; 93:580-586

Grade of dyspnoea	Description
0	Not troubled by breathlessness except on strenuous exercise
1	Shortness of breath when hurrying on the level or walking up a slight hill
2	Walks slower than people of the same age on the level because of breathlessness or has to stop for breath when walking at own pace on the level
3	Stops for breath after walking about 100m or after a few minutes on the level
4	Too breathless to leave the house or breathless when dressing or undressing

Appendix 4 – National Early Warning Score (NEWS)

www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news

The Royal College of Physicians (RCP) has led the development of a new National Early Warning Score (NEWS) report, which advocates standardising the use of a NEWS system across the NHS in order to drive the 'step change' required in the assessment and response to acute illness.

The report, prepared by a working party convened by the Royal College of Physicians' Acute Medicine Task Force, recommends that:

- NEWS should be used when patients present acutely to hospital and also in the prehospital assessment ie by primary care and the ambulance services.
- The Royal College of Physicians (RCP) has led the development of a new National Early Warning Score (NEWS) report, which advocates standardising the use of a NEWS system across the NHS in order to drive the 'step change' required in the assessment and response to acute illness.
- NEWS could also be adopted as a surveillance system for all patients in hospitals for tracking their clinical condition, alerting the clinical team to any medical deterioration and triggering a timely clinical response.

The NEWS is based on a simple scoring system in which a score is allocated to physiological measurements already undertaken when patients present to, or are being monitored in hospital.

A score is allocated to each as they are measured, the magnitude of the score reflecting how extreme the parameter varies from the norm. This score is then aggregated, and uplifted for people requiring oxygen. It is important to emphasise that these parameters are already routinely measured in hospitals and recorded on the clinical chart.

Reprinted with permission from the Royal College of Physicians of London.

PHYSIOLOGICAL PARAMETERS	3	2	1	0	1	2	3
Respiration rate	≤8		9-11	12-20		21-24	≥25
Oxygen saturation	≤91	92-93	94-95	≥96			
Any supplemental oxygen		Yes		No			
Temperature	≤35.0		35.1-36.0	36.1-38.0	38.1-39.0	≥39	
Systolic	≤90	91-100	101-110	111-219			≥220
Heart rate	≤40		41-50	51-90	91-110	111-130	≥131
Level of conciousness				A			V, P, or U

Appendix 5 – The role and structure of NCEPOD

The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) is an independent body to which a corporate commitment has been made by the Medical and Surgical Colleges, Associations and Faculties related to its area of activity. Each of these bodies nominates members on to NCEPOD's Steering Group.

Steering Group as at 7th June 2017

Dr M Nathanson	Association of Anaesthetists of Great Britain and Ireland
Vacancy	Association of Surgeons of Great Britain and Ireland
Mr K Altman	Faculty of Dental Surgery, Royal College of Surgeons of England
Vacancy	Faculty of Public Health Medicine
Mr S Barasi	Lay Representative
Ms S Payne	Lay Representative
Dr J Fazackerley	Royal College of Anaesthetists
Dr K Ramachandran	Royal College of Anaesthetists
Dr J Butler	Faculty of Intensive Care Medicine
Dr C Mann	Royal College of Emergency Medicine
Vacancy	Royal College of General Practitioners
Mrs J Greaves	Royal College of Nursing
Mr T Hillard	Royal College of Obstetricians and Gynaecologists
Mr W Karwatowski	Royal College of Ophthalmologists
Dr I Doughty	Royal College of Paediatrics and Child Health
Dr L Igali	Royal College of Pathologists
Mr M McKirdy	Royal College of Physicians and Surgeons of Glasgow
Dr M Jones	Royal College of Physicians of Edinburgh
Dr A McCune	Royal College of Physicians of London
Dr M Ostermann	Royal College of Physicians of London
Dr M Cusack	Royal College of Physicians of London
Dr J Carlile	Royal College of Psychiatrists
Dr S Ingram	Royal College of Radiologists
Mr W Tennant	Royal College of Surgeons of Edinburgh
Mr J Abercrombie	Royal College of Surgeons of England
Mr M Bircher	Royal College of Surgeons of England

Observers

Dr D Sharpstone	Coroners' Society of England and Wales
Mr J Campbell	Healthcare Quality Improvement Partnership

Trustees

Professor L Regan – Chair
Dr D Mason – Honorary Treasurer
Mr I Martin
Ms J Barber
Professor R Endacott
Professor T J Hendra

NCEPOD is a company, limited by guarantee (Company number: 3019382) and a registered charity (Charity number: 1075588)

Company Secretary Dr M Mason

Clinical Co-ordinators

The Steering Group appoint a Lead Clinical Co-ordinator for a defined tenure. In addition there are 11 Clinical/Nursing Co-ordinators who work on each study. All Co-ordinators are engaged in active academic/clinical practice (in the NHS) during their term of office.

Lead Clinical Co-ordinators	Dr M Juniper (Medicine)
	Dr V Srivastava (Medicine)
Clinical Co-ordinators	Dr K Wilkinson (Anaesthesia)
	Dr A P L Goodwin (Anaesthesia)
	Mr M Sinclair (Surgery)
	Dr S McPherson (Interventional Radiology)
	Ms G Ellis (Nursing)
	Dr K Horridge (Paediatrics)
	Dr M Allsopp (Adolescent Psychiatry)
	Dr A Michalski (Paediatric Oncology)

Lay Representatives

NCEPOD has a number of lay representatives who assist in all aspects of NCEPOD's work.
Richard Carrington | Alice Joy | Ron Newall |Sharon North

Commissioning and supporting organisations

The Clinical Outcome and Review Programme into Medical and Surgical Care is commissioned by the Healthcare Quality Improvement Partnership (HQIP) on behalf of NHS England, NHS Wales, the Health and Social care division of the Scottish Government, the Northern Ireland Department of Health, the States of Jersey, the Bailiwick of Guernsey, and the Isle of Man.

Members of the Clinical Outcome Review Programme into Medical and Surgical Care Independent Advisory Group:

Rachel Binks | Mike Dent | Mark Ferreira | Margaret Hughes
Donal O'Donoghue | Peter Lamont | Terence O'Kelly
Joan Russell | David Saunders | Roger Taylor
William Taylor | Phil Willan | Paddy Woods

The organisations that provided additional funding to cover the cost of this study:

Aspen Healthcare | Beneden Hospital | BMI Healthcare | BUPA Cromwell | East Kent Medical Services Ltd | Fairfield Independent Hospital | HCA International | Hospital of St John and St Elizabeth | King Edward VII's Hospital Sister Agnes | New Victoria Hospital | Nuffield Health | Ramsay Health Care UK | Spire Health Care | St Anthony's Hospital | The Horder Centre | The London Clinic | Ulster Independent Clinic

Appendix 6 – Participation

Trust Name	Number of hospitals participating	Number of organisational questionnaires received	Number of cases selected but subsequently excluded	Number of cases that remained included	Number of clinician questionnaires received	Number of sets of case notes received
Abertawe Bro Morgannwg University Health Board	3	3	9	10	8	10
Aintree Hospitals NHS Foundation Trust	1	1	1	4	3	4
Airedale NHS Foundation Trust	1	1	1	4	2	2
Aneurin Bevan University Health Board	2	2	3	9	4	4
Ashford & St Peter's Hospitals NHS Trust	1	1	1	4	4	4
Barking, Havering & Redbridge University Hospitals NHS Trust	2	2	10	3	3	3
Barnsley Hospital NHS Foundation Trust	1	1	4	1	1	1
Basildon & Thurrock University Hospitals NHS FoundationTrust	1	1	4	2	2	2
Belfast Health and Social Care Trust	3	0	5	10	6	6
Betsi Cadwaladr University Local Health Board	3	0	7	11	2	1
Blackpool Teaching Hospitals NHS Foundation Trust	1	1	5	5	5	5
Bolton Hospital NHS Foundation Trust	1	0	3	2	2	2
Bradford Teaching Hospitals NHS Foundation Trust	1	1	2	3	3	3
Brighton and Sussex University Hospitals NHS Trust	2	2	6	5	3	3
Buckinghamshire Healthcare NHS Trust	1	1	7	5	5	5
Burton Hospitals NHS Foundation Trust	1	1	3	4	4	4
Calderdale & Huddersfield NHS Foundation Trust	2	2	9	6	5	5
Cambridge University Hospitals NHS Foundation Trust	1	1	2	4	4	4
Cardiff and Vale University Health Board	2	0	8	0	0	0
Central Manchester University Hospitals NHS Foundation Trust	2	0	2	6	1	0
Chelsea & Westminster NHS Foundation Trust	1	0	2	3	1	1
Chesterfield Royal Hospital NHS Foundation Trust	1	1	3	5	5	5
City Hospitals Sunderland NHS Foundation Trust	1	1	3	4	4	4
Colchester Hospital University NHS Foundation Trust	1	1	0	0	0	0

Appendix 6 – Participation (continued)

Trust Name	Number of hospitals participating	Number of organisational questionnaires received	Number of cases selected but subsequently excluded	Number of cases that remained included	Number of clinician questionnaires received	Number of sets of case notes received
Countess of Chester Hospital NHS Foundation Trust	1	1	1	4	4	4
County Durham and Darlington NHS Foundation Trust	2	2	7	7	5	7
Croydon Health Services NHS Trust	1	1	2	3	3	3
Cwm Taf University Health Board	2	2	6	5	5	5
Dartford & Gravesham NHS Trust	1	1	0	5	2	2
Derby Teaching Hospitals NHS Foundation Trust	1	1	3	5	3	3
Doncaster and Bassetlaw Hospitals NHS Foundation Trust	2	2	1	7	2	0
Dorset County Hospital NHS Foundation Trust	1	1	2	3	3	3
East & North Hertfordshire NHS Trust	1	1	5	2	2	2
East Cheshire NHS Trust	1	1	3	3	2	1
East Kent Hospitals University NHS Foundation Trust	3	0	2	14	3	3
East Lancashire Hospitals NHS Trust	1	1	0	6	4	0
East Sussex Healthcare NHS Trust	2	2	5	5	4	5
Epsom and St Helier University Hospitals NHS Trust	2	2	2	10	1	0
Frimley Health NHS Foundation Trust	2	2	8	2	2	2
Gateshead Health NHS Foundation Trust	1	1	0	5	5	5
George Eliot Hospital NHS Trust	1	1	0	5	1	1
Gloucestershire Hospitals NHS Foundation Trust	2	1	4	9	4	3
Great Western Hospitals NHS Foundation Trust	1	1	3	2	2	2
Guy's & St Thomas' NHS Foundation Trust	1	1	9	0	0	0
Hampshire Hospitals NHS Foundation Trust	2	2	2	8	4	4
Harrogate and District NHS Foundation Trust	1	1	2	4	1	1
Heart of England NHS Foundation Trust	2	2	4	7	7	5
Hillingdon Hospitals NHS Foundation Trust (The)	1	1	1	4	4	0
Hinchingbrooke Health Care NHS Trust	1	1	3	2	2	2

Trust Name	Number of hospitals participating	Number of organisational questionnaires received	Number of cases selected but subsequently excluded	Number of cases that remained included	Number of clinician questionnaires received	Number of sets of case notes received
Homerton University Hospital NHS Foundation Trust	1	1	1	4	2	1
Hull and East Yorkshire Hospitals NHS Trust	2	2	10	3	3	3
Hywel Dda University Health Board	4	4	10	12	12	12
Imperial College Healthcare NHS Trust	3	2	4	8	6	5
Ipswich Hospital NHS Trust	1	1	2	4	4	4
Isle of Man Department of Health & Social Security	2	1	2	1	0	1
Isle of Wight NHS Trust	1	1	0	5	0	0
James Paget University Hospitals NHS Foundation Trust	1	1	2	4	4	4
Kettering General Hospital NHS Foundation Trust	1	1	2	3	1	1
King's College Hospital NHS Foundation Trust	2	1	3	8	1	1
Kingston Hospital NHS Trust	1	1	3	2	2	2
Lewisham and Greenwich NHS Trust	2	1	2	8	8	8
London North West Healthcare NHS Trust	3	3	7	8	8	8
Luton and Dunstable Hospital NHS Foundation Trust	1	0	3	4	1	0
Maidstone and Tunbridge Wells NHS Trust	2	2	7	4	2	1
Medway NHS Foundation Trust	1	1	2	7	1	1
Mid Cheshire Hospitals NHS Foundation Trust	1	1	0	5	0	0
Mid Essex Hospitals NHS Trust	1	1	6	4	2	1
Mid Yorkshire Hospitals NHS Trust	2	1	6	7	2	6
Milton Keynes University Hospital NHS Foundation Trust	1	1	1	4	3	4
Newcastle upon Tyne Hospitals NHS Foundation Trust	2	0	6	4	2	4
NHS Forth Valley	1	1	0	5	5	0
NHS Grampian	2	2	0	9	7	7
Norfolk & Norwich University Hospital NHS Trust	1	1	4	2	0	2
North Bristol NHS Trust	1	1	3	2	2	2
North Cumbria University Hospitals NHS Trust	2	0	0	10	2	2

Appendix 6 – Participation (continued)

Trust Name	Number of hospitals participating	Number of organisational questionnaires received	Number of cases selected but subsequently excluded	Number of cases that remained included	Number of clinician questionnaires received	Number of sets of case notes received
North Middlesex University Hospital NHS Trust	1	1	4	1	0	1
North Tees and Hartlepool NHS Foundation Trust	1	1	2	4	4	0
Northampton General Hospital NHS Trust	1	1	1	5	5	5
Northern Devon Healthcare NHS Trust	1	1	4	5	5	5
Northern Lincolnshire & Goole NHS Foundation Trust	2	2	4	6	5	6
Northumbria Healthcare NHS Foundation Trust	2	2	10	10	8	7
Nottingham University Hospitals NHS Trust	2	2	8	6	4	3
Oxford University Hospitals NHS Foundation Trust	3	3	4	7	7	7
Pennine Acute Hospitals NHS Trust (The)	3	3	5	10	10	9
Peterborough & Stamford Hospitals NHS Foundation Trust	1	1	0	0	0	0
Plymouth Hospitals NHS Trust	1	1	5	0	0	0
Poole Hospital NHS Foundation Trust	1	1	0	0	0	0
Portsmouth Hospitals NHS Trust	1	1	1	4	2	2
Rotherham NHS Foundation Trust	1	1	2	4	4	4
Royal Berkshire NHS Foundation Trust	1	1	1	3	3	3
Royal Bournemouth and Christchurch Hospitals NHS Trust	1	1	1	5	5	5
Royal Cornwall Hospitals NHS Trust	1	1	2	5	5	5
Royal Devon and Exeter NHS Foundation Trust	1	1	0	5	5	5
Royal Free London NHS Foundation Trust	2	2	7	5	5	5
Royal Liverpool & Broadgreen University Hospitals NHS Trust	1	1	5	3	3	2
Royal Surrey County Hospital NHS Trust	1	1	3	3	3	3
Royal United Hospitals Bath NHS Foundation Trust	1	1	1	4	4	4
Salford Royal Hospitals NHS Foundation Trust	1	1	3	4	4	4
Salisbury NHS FoundationTrust	1	1	3	3	3	3
Sandwell and West Birmingham Hospitals NHS Trust	2	2	10	0	0	0

Trust Name	Number of hospitals participating	Number of organisational questionnaires received	Number of cases selected but subsequently excluded	Number of cases that remained included	Number of clinician questionnaires received	Number of sets of case notes received
Sheffield Teaching Hospitals NHS Foundation Trust	1	1	2	5	5	4
Sherwood Forest Hospitals NHS Foundation Trust	1	1	4	7	7	7
Shrewsbury and Telford Hospitals NHS Trust	2	2	4	6	2	6
South Eastern Health & Social Care Trust	2	1	0	8	4	2
South Tees Hospitals NHS Foundation Trust	2	0	6	6	4	5
South Warwickshire NHS Foundation Trust	1	1	1	4	3	0
Southend University Hospital NHS Foundation Trust	1	1	1	4	0	0
Southern Health & Social Care Trust	2	2	2	8	8	3
Southport and Ormskirk Hospitals NHS Trust	1	0	2	4	0	4
St George's University Hospitals NHS Foundation Trust	1	1	3	4	4	4
St Helens and Knowsley Teaching Hospitals NHS Trust	1	1	1	4	4	4
States of Guernsey Committee for Health & Social Care	1	1	0	0	0	0
States of Jersey Health & Social Services	1	1	3	2	2	2
Tameside and Glossop Integrated Care NHS Foundation Trust	1	1	4	4	4	4
Taunton & Somerset NHS Foundation Trust	1	1	0	5	4	4
The Dudley Group NHS Foundation Trust	1	1	3	2	2	2
The Leeds Teaching Hospitals NHS Trust	2	2	5	7	6	6
The Queen Elizabeth Hospital King's Lynn NHS FoundationTrust	1	1	2	3	0	2
The Royal Wolverhampton Hospitals NHS Trust	1	1	4	4	3	4
The University Hospitals of the North Midlands NHS Trust	2	1	4	9	1	0
Torbay and South Devon NHS Foundation Trust	1	0	2	3	1	0
United Lincolnshire Hospitals NHS Trust	3	3	6	9	9	9
Univ. Hospital of South Manchester NHS Foundation Trust	1	1	9	4	4	4

Appendix 6 – Participation (continued)

Trust Name	Number of hospitals participating	Number of organisational questionnaires received	Number of cases selected but subsequently excluded	Number of cases that remained included	Number of clinician questionnaires received	Number of sets of case notes received
University College London Hospitals NHS Foundation Trust	1	1	4	5	1	1
University Hospital Southampton NHS Foundation Trust	1	1	1	4	4	4
University Hospitals Birmingham NHS Foundation Trust	1	1	4	1	1	1
University Hospitals Coventry and Warwickshire NHS Trust	1	1	3	2	2	2
University Hospitals of Bristol NHS Foundation Trust	1	1	1	4	3	1
University Hospitals of Leicester NHS Trust	3	1	6	9	5	4
University Hospitals of Morecambe Bay NHS Trust	2	2	6	4	4	4
Walsall Healthcare NHS Trust	1	1	2	3	2	2
Warrington & Halton Hospitals NHS Foundation Trust	1	0	1	4	1	1
West Hertfordshire Hospitals NHS Trust	1	1	1	4	3	4
West Suffolk NHS Foundation Trust	1	0	3	3	1	3
Western Health & Social Care Trust	2	2	0	5	3	0
Western Sussex Hospitals NHS Foundation Trust	2	2	5	6	6	6
Whittington Health	1	1	1	5	5	5
Wirral University Teaching Hospital NHS Foundation Trust	1	1	3	2	2	2
Worcestershire Acute Hospitals NHS Trust	2	2	13	6	4	6
Wrightington, Wigan & Leigh NHS Foundation Trust	1	1	0	5	2	3
Wye Valley NHS Trust	1	1	5	0	0	0
Yeovil District Hospital NHS Foundation Trust	1	1	1	4	3	3
York Teaching Hospitals NHS Foundation Trust	2	2	4	6	3	3

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